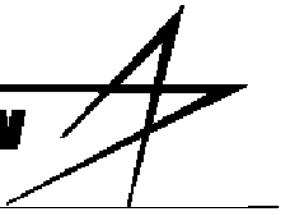


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**Human Research Facility (HRF)
Gas Delivery System
(GDS)**
Preliminary Structural Analysis Report

P/N: SEG46117462-301

LMSEAT-xxxx

ABSTRACT

The component level stress analysis of the Gas Delivery System (GDS), P/N: SEG46117800-301 (drawer), SEG46117699-301 (guide assembly), for the Human Research Facility (HRF), has been completed using loads from SSP 57000 Revision E, Pressurized Payloads Interface Requirement Document. This report presents the preliminary results for the purpose of supporting the GDS CDR. The GDS is housed in a 4PU drawer mounted in the HRF Rack 2 that will be transported to the Space Station onboard a Mini-Pressurized Logistics Module (MPLM) by the Space Shuttle. Several views of the GDS finite element model (FEM) are provided in Figures 3.1 through 3.3.

Integrated Design Engineering Analysis Software (I-DEAS) was used to model the structure and content of the GDS. The model was then translated into National Aeronautics and Space Administration (NASA) Structural Analysis Software (NASTRAN) format where Random Vibration Load Factors (RVLF) were determined using the modal mass participation technique. Random loads were then combined with low frequency quasi-static loads to form 24 load cases. Each load case was applied to the drawer and its contents one at a time in NASTRAN, and static analysis performed to recover element forces and element stresses.

The analyses indicate that positive margins exist for all structural elements of the GDS drawer. Details can be found in the Margin of Safety Table.

Rack level analysis as well as fracture control analysis for the pressure system is still to be done for the GDS when further supporting analysis data becomes available.

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REFERENCE

1. SSP 52005, ISS Payload Flight Equipment Requirements and Guidelines for Safety- Critical Structures, Revision B, ISSP.
2. SSP 57000, ISSP Pressurized Payloads Interface Requirements Document, Revision E, ISSP.
3. Analysis and Design of Flight Vehicle Structures, Bruhn, E.F., Jacobs Publishing, Indianapolis, Indiana, 1973

1.0 INTRODUCTION

This report contains the results of the component level stress analysis of the GDS. Analyses performed include component analysis, crew-induced loads analysis, depressurization/repressurization analysis, containment analysis, fail-safe analysis, and fatigue analysis. Quasi-static lift-off and landing load factors and random vibration levels were obtained from the ISSP Pressurized Payloads Interface Requirements Document, SSP 57000 Rev D. The random load factors are calculated using the Modal Mass Participation and the Miles Equation as Described in SSP 52005 Rev B. Loads used in the depressurization/repressurization analysis and crew induced lads analysis were obtained from SSP 57000 Rev D.

Analyses were performed by finite element method augmented with hand analyses where appropriate. The factors of safety (FS) used are 2.0 for ultimate and 1.25 for yield. For fail-safe analyses, a factor of safety of 1.0 was used.

2.0 **MINIMUM MARGINS OF SAFETY**

Factors of safety for liftoff, landing, and crew-induced loads are 2.0 for ultimate and 1.25 yield for all components. For fail-safe conditions, an ultimate factor of safety of 1.0 was used for all components.

Positive MS, base on the above factors of safety, have been obtained from the analysis. Table 2.1 presents the minimum margins for all structural components for the GDS.

TABLE 2.1 MINIMUM MARGINS OF SAFETY

ITEM AND PART NUMBER OR DRAWING NUMBER	MATERIAL	FAILURE MODE	APPLIED LOAD/STRESS	ALLOWABLE LOADS/STRESS	MINIMUM MS	REFERENCE PAGE
Front Panel	7075-T7351 AL	Ultimate	21760.8 psi	68000 psi (ult)	0.56	17
Back Panel	6061-T6 AL	Ultimate	3141.77 psi	42000 psi (ult)	5.68	27
Top Panel	6061-T6 AL	Ultimate	3211.98 psi	42000 psi (ult)	5.54	34
Bottom Panel	7075-T7351 AL	Ultimate	1412.07 psi	68000 psi (ult)	23.03	26
Right Side Panel	7075-T7351 AL	Ultimate	9226.26 psi	68000 psi (ult)	2.69	18
Left Side Panel	7075-T7351 AL	Ultimate	7429.67 psi	68000 psi (ult)	3.58	31
Bottle Retention Plate	7075-T351 AL	Ultimate	23055.1 psi	68000 psi (ult)	0.47	23
FASTENERS:						
Slide Bar to Side Panels	NAS1101E3-7	Combined Tension & Shear	2083 lbs (T) 200 lbs (S)	2385 lbs 1674 lbs (yield)	0.15	40
Bottom to Side Panels	NAS1102E3-14	Combined Tension & Shear	1973 lbs (T) 9.7 lbs (S)	2385 lbs 1674 lbs (yield)	0.21	38
Bottom to Front Panel	NAS1102E3-14	Combined Tension & Shear	1975 lbs (T) 187 lbs (S)	2385 lbs 1674 lbs (yield)	0.20	39
Bottom to Back Panel	NAS1102E3-14	Combined Tension & Shear	1974 lbs (T) 2.75 lbs (S)	2385 lbs 1674 lbs (yield)	0.21	39
Side to Front Panel	NAS1102E3-10	Combined Tension & Shear	2036 lbs (T) 359 lbs (S)	2385 lbs 1674 lbs (yield)	0.15	41
Side to Back Panel	NAS1102E3-10	Combined Tension & Shear	1975 lbs (T) 8.42 lbs (S)	2385 lbs 1674 lbs (yield)	0.21	41
Side to Top Panel	NAS1102E3-10	Combined Tension & Shear	1965 lbs (T) 29.81 lbs (S)	2385 lbs 1674 lbs (yield)	0.21	38

TABLE 2.1 MINIMUM MARGINS OF SAFETY (CONT)

ITEM AND PART NUMBER OR DRAWING NUMBER	MATERIAL	FAILURE MODE	APPLIED LOAD/STRESS	ALLOWABLE LOADS/STRESS	MINIMUM MS	REFERENCE PAGE
Front Panel to Rack	NAS1352N4LE 16	Combined Tension & Shear	3486 lbs (T) 222.4 lbs (S)	4368 lbs 3034 lbs (yield)	0.31	42
CREW INDUCED LOADS:						
Front Panel SDG46117820-301	7075-T7351 AL	Ultimate	6090 psi	68000 psi (ult)	4.58	43
FAIL-SAFE ANALYSIS:						
Front Panel to Rack	NAS1352	Combined Tension & Shear	3690 lbs (T) 357 lbs (S)	4368 lbs 3034 lbs (yield)	0.25	47

3.0 FEM MODEL

3.1 MODEL DESCRIPTION

A FEM of the GDS was created using Structural Dynamics Research Corporation (SDRC) I-DEAS Master Series 7 software. The FEM was developed to facilitate the dynamic and static stress analysis of the GDS.

The FEM for the GDS drawer is shown in Figures 3-1 through 3-3. The mainframe assembly consists of the front, back top and bottom panels along with two slide bars. The GDS drawer assembly measures approximately 19 inches wide, 24 inches long, 7 inches high, and weighs 43.5 lb without slides as shown in Table 3.1.

TABLE 3.1 GRID POINT WEIGHT GENERATOR CHECK

```
OUTPUT FROM GRID POINT WEIGHT GENERATOR
REFERENCE POINT = 0

      M O
* 4.350020E+01 0.000000E+00 0.000000E+00 0.000000E+00 1.273779E+03 7.253043E+02 *
* 0.000000E+00 4.350020E+01 0.000000E+00 -1.273779E+03 0.000000E+00 1.270047E+03 *
* 0.000000E+00 0.000000E+00 4.350020E+01 -7.253043E+02 -1.270047E+03 0.000000E+00 *
* 0.000000E+00 -1.273779E+03 -7.253043E+02 5.152771E+04 2.116482E+04 -3.719362E+04 *
* 1.273779E+03 0.000000E+00 -1.270047E+03 2.116482E+04 7.607619E+04 2.122356E+04 *
* 7.253043E+02 1.270047E+03 0.000000E+00 -3.719362E+04 2.122356E+04 5.263800E+04 *

      S
* 1.000000E+00 0.000000E+00 0.000000E+00 *
* 0.000000E+00 1.000000E+00 0.000000E+00 *
* 0.000000E+00 0.000000E+00 1.000000E+00 *

      DIRECTION
MASS AXIS SYSTEM (S)      MASS          X-C.G.        Y-C.G.        Z-C.G.
X                  4.350020E+01 0.000000E+00 -1.667359E+01 2.928215E+01
Y                  4.350020E+01 2.919634E+01 0.000000E+00 2.928215E+01
Z                  4.350020E+01 2.919634E+01 -1.667359E+01 0.000000E+00
I(S)
* 2.135290E+03 1.140780E+01 3.924510E+00 *
* 1.140780E+01 1.696478E+03 1.491386E+01 *
* 3.924510E+00 1.491386E+01 3.463865E+03 *
I(Q)
* 2.135576E+03 * *
* 1.696054E+03 * *
* 3.464002E+03 *

      Q
* 9.996568E-01 -2.603743E-02 2.881221E-03 *
* -2.606086E-02 -9.996249E-01 8.418783E-03 *
* 2.660936E-03 -8.490981E-03 -9.999604E-01 *
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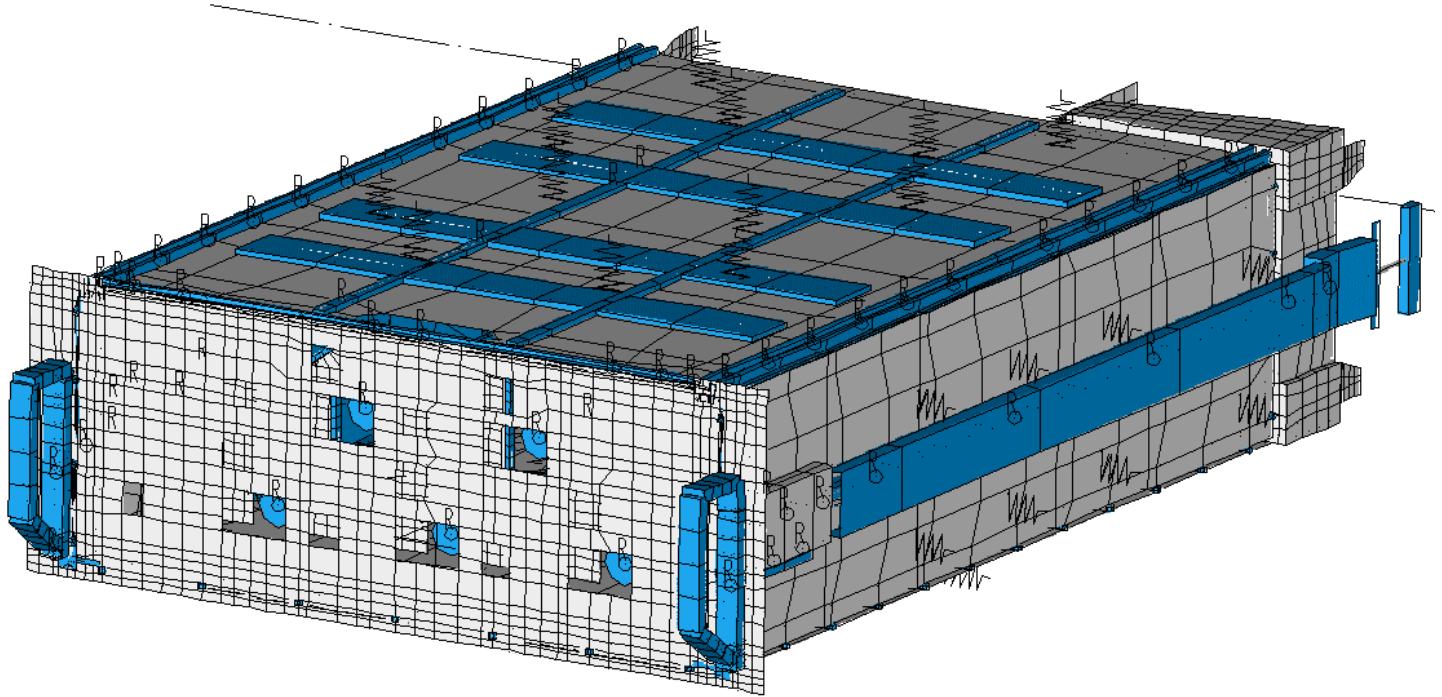


FIGURE 3-1 FRONT ISOMETRIC OF GDS WITH SLIDES FEM

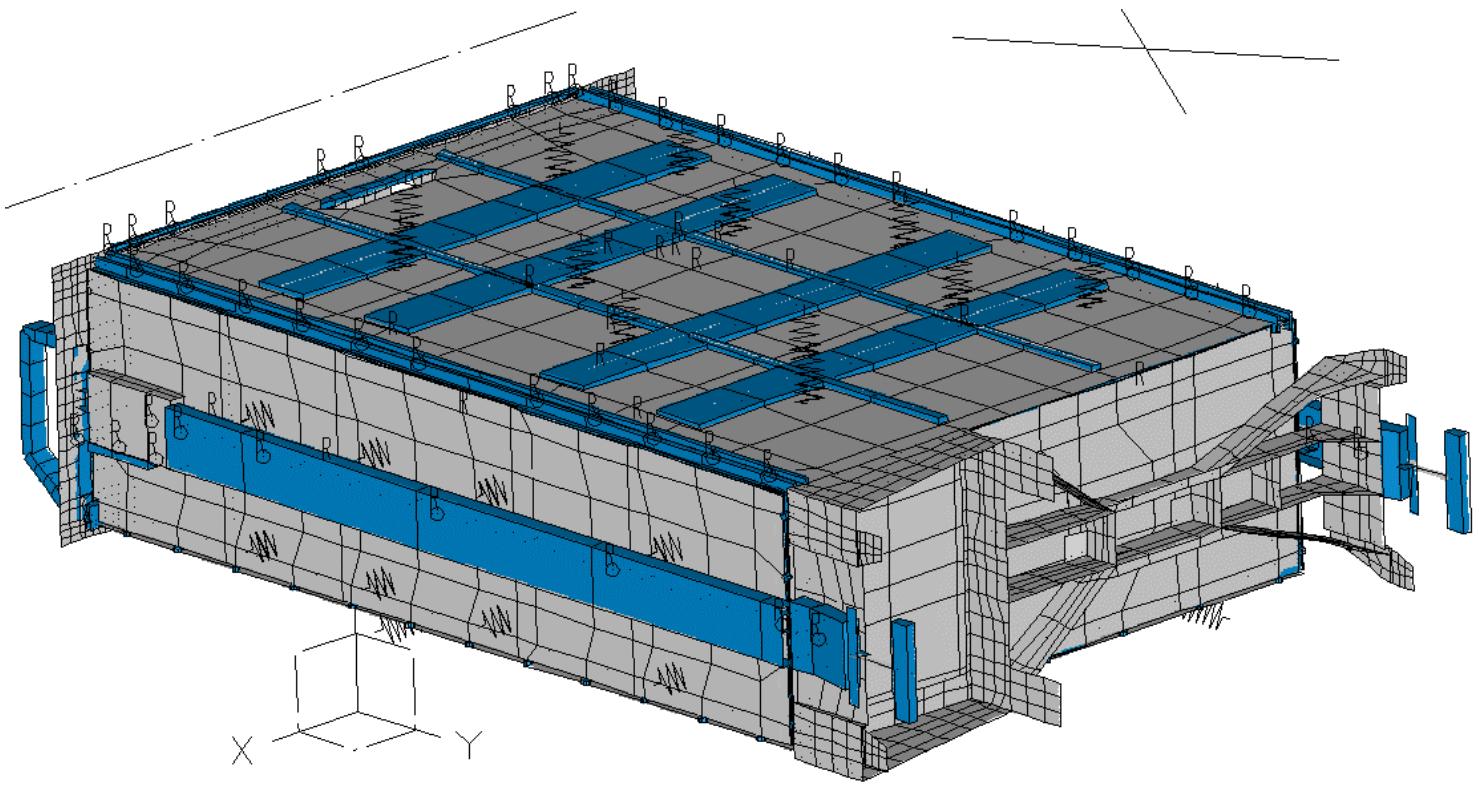


FIGURE 3-2 REAR ISOMETRIC OF GDS WITH SLIDES FEM

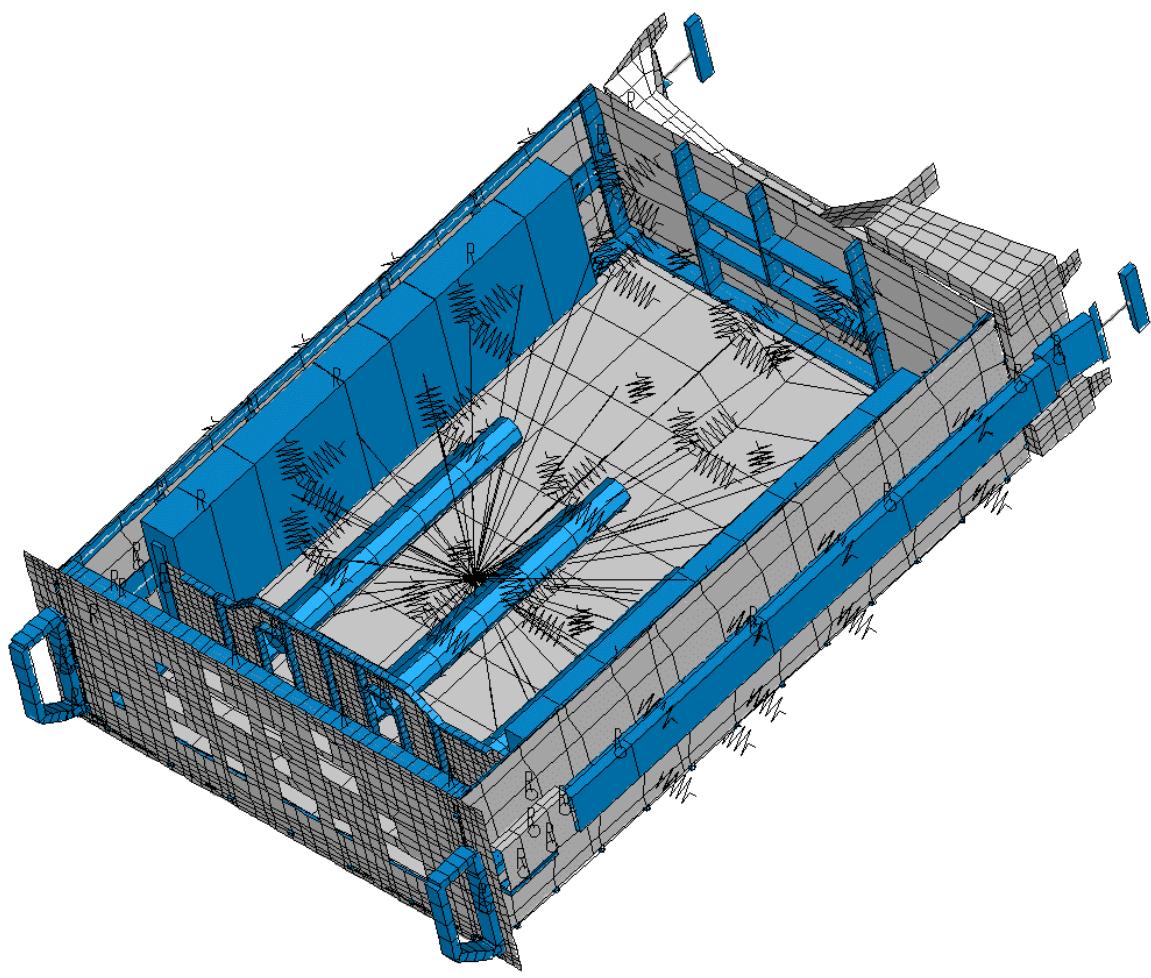


FIGURE 3-3 FRONT ISOMETRIC OF GDS WITH SLIDES AND NO TOP FEM

3.2 MODEL VERIFICATION

The model has been checked for rigid body modes, unit enforced displacements, and natural frequencies. Six rigid body mode frequencies of zero Hertz (Hz) presented in Table 3.2 indicate that the model is free of unintended constraints. Table 3.3 shows the epsilon values that were obtained from unit enforced displacements of the model. All epsilon values were smaller than 0.001. All the computed natural frequencies from a constrained dynamic analysis were more than 35 Hz, which satisfies the component frequency requirement from SSP 52005, Rev. B.

TABLE 3.2 RIGID BODY MODES CHECK

E I G E N V A L U E A N A L Y S I S S U M M A R Y (READ MODULE)

BLOCK SIZE USED	7				
NUMBER OF DECOMPOSITIONS	2				
NUMBER OF ROOTS FOUND	15				
NUMBER OF SOLVES REQUIRED	8				
PAGE 1	JANUARY 15, 2001 MSC.NASTRAN 12/14/99				
0 UNCONSTRAINED WORKSTATION MODES					
MODE NO.	EXTRACTION ORDER	EIGENVALUE	R E A L E I G E N V A L U E S RADIAN S CYCLES	GENERALIZED MASS	GENERALIZED STIFFNESS
1	1	-4.071189E-06	2.017719E-03 3.211299E-04	1.000000E+00	-4.071189E-06
2	2	-1.012608E-06	1.006284E-03 1.601551E-04	1.000000E+00	-1.012608E-06
3	3	-7.201197E-08	2.683505E-04 4.270930E-05	1.000000E+00	-7.201197E-08
4	4	1.574881E-07	3.968477E-04 6.316027E-05	1.000000E+00	1.574881E-07
5	5	6.344162E-07	7.965025E-04 1.267673E-04	1.000000E+00	6.344162E-07
6	6	1.436574E-06	1.198572E-03 1.907586E-04	1.000000E+00	1.436574E-06
7	7	3.509457E+04	1.873354E+02 2.981536E+01	1.000000E+00	3.509457E+04
8	8	3.912018E+04	1.977882E+02 3.147897E+01	1.000000E+00	3.912018E+04
9	9	6.144614E+04	2.478833E+02 3.945185E+01	1.000000E+00	6.144614E+04
10	10	7.494937E+04	2.737688E+02 4.357166E+01	1.000000E+00	7.494937E+04
11	11	7.596477E+04	2.756171E+02 4.386582E+01	1.000000E+00	7.596477E+04
12	12	7.998597E+04	2.828179E+02 4.501187E+01	1.000000E+00	7.998597E+04
13	13	9.231806E+04	3.038389E+02 4.835746E+01	1.000000E+00	9.231806E+04
14	14	1.039183E+05	3.223636E+02 5.130576E+01	1.000000E+00	1.039183E+05
15	15	1.145068E+05	3.383885E+02 5.385620E+01	1.000000E+00	1.145068E+05

TABLE 3.3 EPSILON CHECK

LOAD SEQ. NO. 0.001 ARE FLAGGED WITH ASTERISKS	EPSILON	EXTERNAL WORK	EPSILONS LARGER THAN
1	-1.0804560E-13	6.0138175E+05	
2	-5.7785320E-15	1.6677614E+06	
3	7.4528642E-15	2.0541204E+06	
4	1.3118415E-15	3.0541696E+08	
5	-6.7956975E-15	1.5306818E+08	
6	-1.6207012E-14	1.9354574E+08	

4.0 **LOADS DEFINITION**

The GDS Drawer Assembly is scheduled to be flown in HRF Rack 2. The loads are a combination of quasi-static and random vibration loads. This section provides the quasi-static loads and calculations of random vibration loads for the GDS.

4.1 QUASI-STATIC LOADS

Quasi-static load factors from ISSP Pressurized Payloads Interface Requirements Document, SSP 57000 Rev E were used in the analysis and are presented below.

	Lift-off Load factors (g)			Landing Load Factors (g)		
	X	Y	Z	X	Y	Z
Maximum	+7.7	+11.6	+9.9	+5.4	+7.7	+8.8
Minimum	-7.7	-11.6	-9.9	-5.4	-7.7	-8.8

TABLE 4.1 PAYLOAD ISPR MOUNTED EQUIPMENT LOAD FACTORS, TABLE 3.1.1.3-4, SSP 57000, REV D

The quasi-static lift-off loads are higher than the quasi-static landing loads; therefore, only the lift-off loads were used for the analysis.

4.2 RANDOM VIBRATION LOADS

The random vibration loads acting on payload flight equipment result from the structural response of the equipment component to induce random disturbances from the propulsion system during launch. These high frequency disturbances result in both mechanical and acoustic borne excitation, and occur during the launch phase only (lift-off and ascent) while the main engines are operating.

In order to assess random vibration loads in hardware analysis, several simplifying assumptions must be made. Equivalent static load factors are generally calculated in each axis so they may be combined with low frequency load factors and used in structural analysis. Random Vibration Load Factors (RVLF) are typically calculated from the applicable random vibration criteria using Miles' Equation, which is based upon statistical analyses of induced acceleration spectra with a 3-sigma distribution. Miles' equation determines a load factor by assuming that the fundamental (first system) mode in each orthogonal direction will provide the primary response:

$$RVLF_n = \sqrt{\frac{P}{2} * Q * f_n * PSD_n}$$

where,

f_n = Natural frequency (n=x,y,z)
 Q = Amplification factor
 PSD_n = Random vibration environment Power Spectral Density

The Power Spectral Densities (PSD) values were determined from the GDS natural frequency, (f_n), and the design random vibration environment obtained from SSP 57000, Rev D.

LOCATION	FREQUENCY	LEVEL
Input to rack-mounted equipment	20 Hz	0.005 g^2/Hz
	20-70 Hz	+5.0 Db/octave
	70-200 Hz	0.04 g^2/Hz
	200 – 2000 Hz	-3.9 Db/octave
	2000 Hz	.002 g^2/Hz
	Composite	4.4 g_{rms}

Legend:
 g_{rms} = gravity (g), root mean square

TABLE 4.2 RANDOM VIBRATION CRITERIA FOR U.S. ISPR POST-MOUNTED EQUIPMENT IN THE MPLM, TABLE 3.1.1.3-2, SSP 57000, REV D

If the frequency of interest (f_n) falls on either a positive or negative slope of the input spectrum, the following equation is used to interpolate for the PSD_n value:

$$PSD_n = PSD_1 \left(\frac{f_n}{f_1} \right)^{0.3322^*S}$$

where,

f_1 = Reference frequency (at start of slope)
 f_n = Frequency of interest
 S = Slope of the PSD curve at frequencies above f_1 (Db/octave)
 PSD_1 = Power Spectral Density at f_1

The amplification factor (Q) is chosen based on component mass, support structure flexibility and method of attachment. For most components, a Q of 10 for all three directions should be used if no test data is available.

The GDS natural frequencies were determined by constrained normal modes analysis. For the GDS, the fundamental mode in the X, Y, and Z direction did not have a majority of the mass participating; thus, the modal mass participation method was used to provide a more realistic, less conservative random load factor by multiplying the RVLF for each mode by a ratio of the effective mass participating in the mode to the total component mass, and root-sum-squaring it with the other system modes.

Sample Calculation of RVLF

From the dynamic analysis, the first mode of the GDS is 38.8 Hz.

The power spectral density for the first mode will be:

$$\text{PSD} := .005 \cdot \left(\frac{38.8}{20} \right)^{.33225} \quad \text{PSD} = 0.015$$

The random load factor for the first mode will be:

$$\text{RVLF}_1 := 3 \cdot \sqrt{\frac{\pi}{2} \cdot 10 \cdot 38.8 \cdot 0.015} \quad \text{RVLF}_1 = 9.071$$

The random load factor multiplied by the mass ratio for the first mode will be:

X-direction,

$$\text{RVLF}_{\text{mw}} := 9.071 \cdot \left(\frac{8.21 \cdot 10^{-6} \cdot 386.4}{43.5} \right) \quad \text{RVLF}_{\text{mw}} = 6.615 \cdot 10^{-4}$$

Y-direction

$$\text{RVLF}_{\text{mw}} := 9.071 \cdot \left(\frac{3.04 \cdot 10^{-4} \cdot 386.4}{43.5} \right) \quad \text{RVLF}_{\text{mw}} = 0.024$$

Z-direction

$$\text{RVLF}_{\text{mw}} := 9.071 \cdot \left(\frac{.0278 \cdot 386.4}{43.5} \right) \quad \text{RVLF}_{\text{mw}} = 2.24$$

The mass-weighted RVLF for each mode from 0 to 2000 Hz is computed in the X-direction, Y-direction, and Z-direction as demonstrated above and root-sum-squared to determine the composite RVLF for that axis. Thus the composite RVLF are:

$$\text{RVLF}_x = 8.76 \text{ g} \quad \text{RVLF}_y = 10.37 \text{ g} \quad \text{RVLF}_z = 7.89 \text{ g}$$

4.3 LOAD COMBINATIONS

The quasi-static and random load factors are combined according to SSP 52005 rev B Table 4.1.2-1 to generate 24 load combinations. Table 4.2 summarized the load combination criteria.

TABLE 4.3 LOAD COMBINATION CRITERIA FOR SPACE STATION COMPONENTS

LOAD IN EACH AXIS ACTING SIMULTANEOUSLY						
LOAD SET	ORBITER X _o AXIS	ORBITER Y _o AXIS	ORBITER Z _o AXIS	θ_1 (ABOUT X _o)	θ_2 (ABOUT Y _o)	θ_3 (ABOUT Z _o)
Lift-off	$1.5 \pm [(T_1 - 1.5)^2 + R_1^2]^{0.5}$	$\pm T_2$	$\pm T_3$	$\pm TRF_1$	$\pm TRF_2$	$\pm TRF_3$
	$\pm T_1$	$\pm (T_2^2 + R_2^2)^{0.5}$	$\pm T_3$	$\pm TRF_1$	$\pm TRF_2$	$\pm TRF_3$
	$\pm T_1$	$\pm T_2$	$\pm (T_3^2 + R_3^2)^{0.5}$	$\pm TRF_1$	$\pm TRF_2$	$\pm TRF_3$
	$\pm T_1$	$\pm T_2$	$\pm T_3$	$\pm TRF_1$	$\pm TRF_2$	$\pm TRF_3$

Where:

T_i = Low frequency transient load factor in the i th direction (g's) (includes steady-state acceleration of 1.5 g's for x-direction during lift-off and 1.0 g's in z-direction during landing). The magnitude of T_i may be different, depending on the direction (+ or -) of the low frequency transient load.

R_i = Random load factor in the i th direction (g's)

TRF_i = Low frequency transient rotational load factor about the i th axis (rad/sec²)

Using the above combination method the 24 load cases were developed which are presented in Table 4.3.

TABLE 4.4 24 COMBINED LOAD CASES

Load Case	Quasi-Static Load Factor			Random Vibration Load Factor			Combined Load Factor		
	X	Y	Z	X	Y	Z	X	Y	Z
Lift-off									
1	7.7	11.6	9.9	8.76			12.23	11.60	9.90
2	7.7	11.6	-9.9	8.76			12.23	11.60	-9.90
3	7.7	-11.6	9.9	8.76			12.23	-11.60	9.90
4	7.7	-11.6	-9.9	8.76			12.23	-11.60	-9.90
5	-7.7	11.6	9.9	-8.76			-11.20	11.60	9.90
6	-7.7	11.6	-9.9	-8.76			-11.20	11.60	-9.90
7	-7.7	-11.6	9.9	-8.76			-11.20	-11.60	9.90
8	-7.7	-11.6	-9.9	-8.76			-11.20	-11.60	-9.90
Lift-off									
1	7.7	11.6	9.9		10.37		7.70	15.56	9.90
2	7.7	11.6	-9.9		10.37		7.70	15.56	-9.90
3	7.7	-11.6	9.9		-10.37		7.70	-15.56	9.90
4	7.7	-11.6	-9.9		-10.37		7.70	-15.56	-9.90
5	-7.7	11.6	9.9		10.37		-7.70	15.56	9.90
6	-7.7	11.6	-9.9		10.37		-7.70	15.56	-9.90
7	-7.7	-11.6	9.9		-10.37		-7.70	-15.56	9.90
8	-7.7	-11.6	-9.9		-10.37		-7.70	-15.56	-9.90
Lift-off									
1	7.7	11.6	9.9			7.89	7.70	11.60	12.66
2	7.7	11.6	-9.9			-7.89	7.70	11.60	-12.66
3	7.7	-11.6	9.9			7.89	7.70	-11.60	12.66
4	7.7	-11.6	-9.9			-7.89	7.70	-11.60	-12.66
5	-7.7	11.6	9.9			7.89	-7.70	11.60	12.66
6	-7.7	11.6	-9.9			-7.89	-7.70	11.60	-12.66
7	-7.7	-11.6	9.9			7.89	-7.70	-11.60	12.66
8	-7.7	-11.6	-9.9			-7.89	-7.70	-11.60	-12.66

5.0 COMPONENT ANALYSIS

The combined loads generated in Section 4.0 were used for static analysis of the model performed with MSC/NASTRAN software. The results were post processed using a customized Formula Translator (FORTRAN) program which computes the MS and sorts the output based on the lowest MS.

5.1 Plate Element Analysis

The lowest MS for the plate elements representing the six panel walls of the GDS are presented in Table 5.1-5.7. The MS for the plate elements are computed based on the von Mises or Principal stress. The following explains the algorithm used in the derivation of von Mises stress and MS for each plate element.

A customized FORTRAN program computes the MS and sorts the NASTRAN output based on the lowest MS. Von Mises stresses are computed based on the Octahedral Shear Stress Theory (Ref. Bruhn, p. C1.9) for biaxial stress system.

$$\text{Von Mises stress, } \sigma_v = \sqrt{\sigma_1^2 - (\sigma_1 * \sigma_2) + \sigma_2^2}$$

where,

σ_1, σ_2 = Principal stresses

The MS is then calculated using the following equation:

$$MS = \frac{F_t}{FS * \sigma} - 1$$

where,

F_t = Ultimate or yield allowable stress

FS = Factor of safety, 2.0 for ultimate and 1.25 for yield

The highest stress is observed on the bottle retention plate and is 23055.11 psi and is on element 10056. Using this stress value the MS is:

$$MS_{ult} = \frac{68000}{2.0 \cdot 23055.11} - 1 \quad MS_{ult} = 0.475$$

$$MS_{yld} = \frac{57000}{1.25 \cdot 23055.11} - 1 \quad MS_{yld} = 1.096$$

The results for the plate stresses are presented in the following tables.

TABLE 5.1 FRONT PANEL PLATE STRESSES

DATABASE: static1.f06
 OUTPUT FILE: frontpanel.out

ID	LOADID	DISTANCE	FIBRE	STRESSES IN ELEMENT COORD SYSTEM	PRINCIPAL STRESSES (ZERO SHEAR)	VON MISES	
			NORMAL-X	NORMAL-Y	SHEAR-XY		
10056	1	-6.300000E-02	2.172980E+04	4.889229E+03	-7.231452E+02	-2.4543	21760.80 4858.23 19784.23
10056	8	-6.300000E-02	-2.172980E+04	-4.889229E+03	7.231452E+02	87.5457	-4858.23 -21760.80 19784.23
10056	16	-6.300000E-02	-2.112524E+04	-4.785012E+03	6.274986E+02	87.8040	-4760.95 -21149.30 19216.37
10056	9	-6.300000E-02	2.112524E+04	4.785012E+03	-6.274986E+02	-2.1960	21149.30 4760.95 19216.37
10056	7	-6.300000E-02	-2.072103E+04	-4.476336E+03	7.521324E+02	87.3547	-4441.59 -20755.77 18929.90
10056	2	-6.300000E-02	2.072103E+04	4.476336E+03	-7.521324E+02	-2.6453	20755.77 4441.59 18929.90
10056	15	-6.300000E-02	-2.011646E+04	-4.372120E+03	6.564858E+02	87.6165	-4344.79 -20143.79 18361.07
10056	10	-6.300000E-02	2.011646E+04	4.372120E+03	-6.564858E+02	-2.3835	20143.79 4344.79 18361.07
10057	1	-6.300000E-02	5.236853E+03	1.866090E+04	-2.808270E+03	-78.6479	19224.70 4673.05 17366.31
10057	8	-6.300000E-02	-5.236853E+03	-1.866090E+04	2.808270E+03	11.3521	-4673.05 -19224.70 17366.31
10057	7	-6.300000E-02	-5.520855E+03	-1.846330E+04	2.889202E+03	12.0296	-4905.17 -19078.98 17160.50
10057	2	-6.300000E-02	5.520855E+03	1.846330E+04	-2.889202E+03	-77.9704	19078.98 4905.17 17160.50
10057	16	-6.300000E-02	-5.169812E+03	-1.819203E+04	2.750524E+03	11.4505	-4612.69 -18749.15 16921.10
10057	9	-6.300000E-02	5.169812E+03	1.819203E+04	-2.750524E+03	-78.5495	18749.15 4612.69 16921.10
10057	10	-6.300000E-02	5.453814E+03	1.799443E+04	-2.831456E+03	-77.8488	18604.09 4844.16 16716.96
10057	15	-6.300000E-02	-5.453814E+03	-1.799443E+04	2.831456E+03	12.1512	-4844.16 -18604.09 16716.96
10056	17	-6.300000E-02	1.851371E+04	4.210153E+03	-5.592501E+02	-2.2356	18535.54 4188.32 16836.74
10056	24	-6.300000E-02	-1.851371E+04	-4.210153E+03	5.592501E+02	87.7644	-4188.32 -18535.54 16836.74
10263	5	-6.300000E-02	1.808494E+04	3.488320E+03	6.171949E+02	2.4169	18110.99 3462.27 16652.03
10263	4	-6.300000E-02	-1.808494E+04	-3.488320E+03	-6.171949E+02	-87.5831	-3462.27 -18110.99 16652.03
10057	8	6.250000E-02	5.683435E+03	1.698055E+04	-3.632354E+03	-73.6283	18047.66 4616.32 16239.29
10057	1	6.250000E-02	-5.683435E+03	-1.698055E+04	3.632354E+03	16.3717	-4616.32 -18047.66 16239.29
10056	1	6.250000E-02	-1.767766E+04	-4.318852E+03	1.471115E+03	83.7896	-4158.77 -17837.74 16164.70
10056	8	6.250000E-02	1.767766E+04	4.318852E+03	-1.471115E+03	-6.2104	17837.74 4158.77 16164.70
10057	9	6.250000E-02	-5.492521E+03	-1.664801E+04	3.600682E+03	16.4220	-4431.28 -17709.25 15961.81
10057	16	6.250000E-02	5.492521E+03	1.664801E+04	-3.600682E+03	-73.5780	17709.25 4431.28 15961.81
10057	7	6.250000E-02	5.430047E+03	1.676904E+04	-3.191434E+03	-75.3121	17605.58 4593.51 15817.24
10057	2	6.250000E-02	-5.430047E+03	-1.676904E+04	3.191434E+03	14.6879	-4593.51 -17605.58 15817.24
10263	12	-6.300000E-02	-1.757813E+04	-3.436187E+03	-5.054966E+02	-87.9555	-3418.14 -17596.17 16160.53
10263	13	-6.300000E-02	1.757813E+04	3.436187E+03	5.054966E+02	2.0445	17596.17 3418.14 16160.53

TABLE 5.2 RIGHT SIDE PANEL PLATE STRESSES

DATABASE: static1.f06
 OUTPUT FILE: rightside.out

ID	LOADID	DISTANCE	FIBRE	STRESSES	IN ELEMENT COORD SYSTEM	PRINCIPAL STRESSES (ZERO SHEAR)	VON MISES		
			NORMAL-X	NORMAL-Y	SHEAR-XY	ANGLE			
1501	5	-4.000000E-02	3.102156E+03	4.798206E+02	-1.401424E+03	-23.4529	3710.14	-128.17	3775.86
1501	4	-4.000000E-02	-3.102156E+03	-4.798206E+02	1.401424E+03	66.5471	128.17	-3710.14	3775.86
1501	4	4.000000E-02	-3.185842E+03	-9.815959E+02	1.165530E+03	66.6992	-479.62	-3687.82	3472.94
1501	5	4.000000E-02	3.185842E+03	9.815959E+02	-1.165530E+03	-23.3008	3687.82	479.62	3472.94
1501	12	-4.000000E-02	-3.042467E+03	-4.799807E+02	1.329984E+03	66.9653	85.51	-3607.96	3651.47
1501	13	-4.000000E-02	3.042467E+03	4.799807E+02	-1.329984E+03	-23.0347	3607.96	-85.51	3651.47
1501	13	4.000000E-02	3.098289E+03	9.468540E+02	-1.121411E+03	-23.0957	3576.51	468.63	3366.75
1501	12	4.000000E-02	-3.098289E+03	-9.468540E+02	1.121411E+03	66.9043	-468.63	-3576.51	3366.75
1501	6	-4.000000E-02	2.911536E+03	7.055900E+02	-1.116145E+03	-22.6700	3377.74	239.38	3264.64
1501	3	-4.000000E-02	-2.911536E+03	-7.055900E+02	1.116145E+03	67.3300	-239.38	-3377.74	3264.64
1501	14	-4.000000E-02	2.851847E+03	7.057501E+02	-1.044704E+03	-22.1166	3276.41	281.19	3145.26
1501	11	-4.000000E-02	-2.851847E+03	-7.057501E+02	1.044704E+03	67.8834	-281.19	-3276.41	3145.26
1501	6	4.000000E-02	2.896810E+03	6.435293E+02	-9.834202E+02	-20.5582	3265.63	274.71	3137.31
1501	3	4.000000E-02	-2.896810E+03	-6.435293E+02	9.834202E+02	69.4418	-274.71	-3265.63	3137.31
1501	20	-4.000000E-02	-2.664660E+03	-3.688648E+02	1.217788E+03	66.6539	156.76	-3190.28	3271.48
1501	21	-4.000000E-02	2.664660E+03	3.688648E+02	-1.217788E+03	-23.3461	3190.28	-156.76	3271.48
1501	21	4.000000E-02	2.740019E+03	8.884576E+02	-1.012352E+03	-23.7788	3186.07	442.40	2989.52
1501	20	4.000000E-02	-2.740019E+03	-8.884576E+02	1.012352E+03	66.2212	-442.40	-3186.07	2989.52
1501	14	4.000000E-02	2.809258E+03	6.087874E+02	-9.392829E+02	-20.2439	3155.66	262.38	3033.00
1501	11	4.000000E-02	-2.809258E+03	-6.087874E+02	9.392829E+02	69.7561	-262.38	-3155.66	3033.00
1501	19	-4.000000E-02	-2.431115E+03	-6.515172E+02	8.668140E+02	67.8748	-299.10	-2783.53	2646.69
1501	22	-4.000000E-02	2.431115E+03	6.515172E+02	-8.668140E+02	-22.1252	2783.53	299.10	2646.69
1501	19	4.000000E-02	-2.383074E+03	-4.649320E+02	7.848861E+02	70.3519	-184.70	-2663.30	2575.92
1501	22	4.000000E-02	2.383074E+03	4.649320E+02	-7.848861E+02	-19.6481	2663.30	184.70	2575.92
1502	14	-4.000000E-02	1.696080E+03	7.679040E+02	1.265273E+03	34.9288	2579.69	-115.71	2639.45
1502	11	-4.000000E-02	-1.696080E+03	-7.679040E+02	-1.265273E+03	-55.0712	115.71	-2579.69	2639.45
1502	6	-4.000000E-02	1.732869E+03	7.570305E+02	1.225270E+03	34.1434	2563.79	-73.90	2601.53
1502	3	-4.000000E-02	-1.732869E+03	-7.570305E+02	-1.225270E+03	-55.8566	73.90	-2563.79	2601.53
1512	24	4.000000E-02	1.007174E+03	2.425068E+03	1.429908E+02	84.2984	2439.34	992.90	2124.67
1512	17	4.000000E-02	-1.007174E+03	-2.425068E+03	-1.429908E+02	-5.7016	-992.90	-2439.34	2124.67

TABLE 5.3 LEFT SIDE PANEL PLATE STRESSES

DATABASE: static1.f06
 OUTPUT FILE: leftside.out

ID	LOADID	FIBRE DISTANCE	STRESSES IN ELEMENT COORD SYSTEM			PRINCIPAL ANGLE	STRESSES (ZERO SHEAR)			VON MISES
			NORMAL-X	NORMAL-Y	SHEAR-XY		MAJOR	MINOR		
1001	1	4.000000E-02	3.122860E+03	5.303330E+02	-1.420295E+03	-23.8071	3749.49	-96.30	3798.56	
1001	8	4.000000E-02	-3.122860E+03	-5.303330E+02	1.420295E+03	66.1929	96.30	-3749.49	3798.56	
1001	8	-4.000000E-02	-3.235623E+03	-9.348950E+02	1.198342E+03	66.9149	-424.13	-3746.39	3553.36	
1001	1	-4.000000E-02	3.235623E+03	9.348950E+02	-1.198342E+03	-23.0851	3746.39	424.13	3553.36	
1001	16	4.000000E-02	-3.051882E+03	-5.279363E+02	1.343410E+03	66.6048	53.27	-3633.09	3660.02	
1001	9	4.000000E-02	3.051882E+03	5.279363E+02	-1.343410E+03	-23.3952	3633.09	-53.27	3660.02	
1001	9	-4.000000E-02	3.136123E+03	8.975486E+02	-1.148688E+03	-22.8714	3620.67	413.00	3432.85	
1001	16	-4.000000E-02	-3.136123E+03	-8.975486E+02	1.148688E+03	67.1286	-413.00	-3620.67	3432.85	
1001	7	4.000000E-02	-2.878168E+03	-7.635403E+02	1.110404E+03	66.7985	-287.59	-3354.12	3219.98	
1001	2	4.000000E-02	2.878168E+03	7.635403E+02	-1.110404E+03	-23.2015	3354.12	287.59	3219.98	
1001	17	-4.000000E-02	2.795654E+03	8.536795E+02	-1.044034E+03	-23.5381	3250.44	398.90	3070.49	
1001	24	-4.000000E-02	-2.795654E+03	-8.536795E+02	1.044034E+03	66.4619	-398.90	-3250.44	3070.49	
1001	2	-4.000000E-02	2.876668E+03	5.625073E+02	-9.925223E+02	-20.3112	3244.03	195.14	3151.00	
1001	7	-4.000000E-02	-2.876668E+03	-5.625073E+02	9.925223E+02	69.6888	-195.14	-3244.03	3151.00	
1001	10	4.000000E-02	2.807191E+03	7.611436E+02	-1.033519E+03	-22.6462	3238.38	329.95	3086.66	
1001	15	4.000000E-02	-2.807191E+03	-7.611436E+02	1.033519E+03	67.3538	-329.95	-3238.38	3086.66	
1001	24	4.000000E-02	-2.692828E+03	-4.120383E+02	1.237397E+03	66.3320	130.32	-3235.19	3302.27	
1001	17	4.000000E-02	2.692828E+03	4.120383E+02	-1.237397E+03	-23.6680	3235.19	-130.32	3302.27	
1001	15	-4.000000E-02	-2.777169E+03	-5.251609E+02	9.428683E+02	70.0293	-182.53	-3119.80	3032.66	
1001	10	-4.000000E-02	2.777169E+03	5.251609E+02	-9.428683E+02	-19.9707	3119.80	182.53	3032.66	
1001	18	4.000000E-02	2.393230E+03	7.020205E+02	-8.570514E+02	-22.6926	2751.61	343.64	2596.90	
1001	23	4.000000E-02	-2.393230E+03	-7.020205E+02	8.570514E+02	67.3074	-343.64	-2751.61	2596.90	
1001	23	-4.000000E-02	-2.353772E+03	-3.894064E+02	7.870591E+02	70.6468	-112.96	-2630.22	2575.60	

TABLE 5.4 BOTTOM PANEL PLATE STRESSES

DATABASE: static1.f06
 OUTPUT FILE: bottom.out

ID	LOADID	FIBRE DISTANCE	STRESSES IN ELEMENT COORD SYSTEM			PRINCIPAL STRESSES (ZERO SHEAR)			VON MISES
			NORMAL-X	NORMAL-Y	SHEAR-XY	ANGLE	MAJOR	MINOR	
2010	5	1.500000E-01	9.177988E+01	7.759901E+02	-2.357590E+01	-88.0289	776.80	90.97	735.55
2010	4	1.500000E-01	-9.177988E+01	-7.759901E+02	2.357590E+01	1.9711	-90.97	-776.80	735.55
2012	4	-1.500000E-01	-1.741923E+02	-7.157450E+02	1.487003E+02	14.3870	-136.05	-753.89	695.91
2012	5	-1.500000E-01	1.741923E+02	7.157450E+02	-1.487003E+02	-75.6130	753.89	136.05	695.91
2010	13	1.500000E-01	9.078719E+01	7.479409E+02	-5.494941E+00	-89.5210	747.99	90.74	707.00
2010	12	1.500000E-01	-9.078719E+01	-7.479409E+02	5.494941E+00	0.4790	-90.74	-747.99	707.00
2009	1	1.500000E-01	9.198338E+01	7.425339E+02	3.285515E+01	87.1161	744.19	90.33	703.39
2009	8	1.500000E-01	-9.198338E+01	-7.425339E+02	-3.285515E+01	-2.8839	-90.33	-744.19	703.39
2011	1	-1.500000E-01	1.718965E+02	6.991727E+02	1.535648E+02	74.8900	740.64	130.43	684.80
2011	8	-1.500000E-01	-1.718965E+02	-6.991727E+02	-1.535648E+02	-15.1100	-130.43	-740.64	684.80
2012	13	-1.500000E-01	1.600049E+02	6.911682E+02	-1.608565E+02	-74.3988	736.08	115.09	685.82
2012	12	-1.500000E-01	-1.600049E+02	-6.911682E+02	1.608565E+02	15.6011	-115.09	-736.08	685.82
2010	6	1.500000E-01	3.577396E+01	6.374042E+02	-2.605175E+02	-69.5531	734.53	-61.35	767.05
2010	3	1.500000E-01	-3.577396E+01	-6.374042E+02	2.605175E+02	20.4469	61.35	-734.53	767.05
2012	20	-1.500000E-01	-1.840393E+02	-6.622771E+02	1.817813E+02	18.6213	-122.79	-723.53	670.62
2012	21	-1.500000E-01	1.840393E+02	6.622771E+02	-1.817813E+02	-71.3787	723.53	122.79	670.62
2011	16	-1.500000E-01	-1.567837E+02	-6.722644E+02	1.655606E+02	-16.3574	-108.19	-720.86	673.31
2011	9	-1.500000E-01	1.567837E+02	6.722644E+02	1.655606E+02	73.6426	720.86	108.19	673.31
2011	24	-1.500000E-01	-1.817539E+02	-6.494192E+02	1.851593E+02	-19.1869	-117.32	-713.85	663.02
2011	17	-1.500000E-01	1.817539E+02	6.494192E+02	1.851593E+02	70.8131	713.85	117.32	663.02
2009	9	1.500000E-01	9.114494E+01	7.134674E+02	1.334243E+01	88.7723	713.75	90.86	672.94
2009	16	1.500000E-01	-9.114494E+01	-7.134674E+02	-1.334243E+01	-1.2277	-90.86	-713.75	672.94

TABLE 5.5 TOP PANEL PLATE STRESSES

DATABASE: static1.f06

OUTPUT FILE: top.out

ID	LOADID	FIBRE DISTANCE	STRESSES IN ELEMENT COORD SYSTEM			PRINCIPAL ANGLE	STRESSES (ZERO SHEAR)			VON MISES
			NORMAL-X	NORMAL-Y	SHEAR-XY		MAJOR	MINOR		
2525	18	6.250000E-02	-2.073302E+03	-1.132478E+02	-1.791883E+02	-84.8192	-97.00	-2089.55	2042.78	
2525	23	6.250000E-02	2.073302E+03	1.132478E+02	1.791883E+02	5.1808	2089.55	97.00	2042.78	
2519	18	-6.300000E-02	2.072503E+03	1.147802E+02	-1.610549E+02	-4.6717	2085.66	101.62	2036.76	
2519	23	-6.300000E-02	-2.072503E+03	-1.147802E+02	1.610549E+02	85.3283	-101.62	-2085.66	2036.76	
2523	18	6.250000E-02	-2.078479E+03	-3.273703E+01	-1.847127E+01	-89.4827	-32.57	-2078.65	2062.55	
2523	23	6.250000E-02	2.078479E+03	3.273703E+01	1.847127E+01	0.5173	2078.65	32.57	2062.55	
2519	22	6.250000E-02	-2.057524E+03	-1.104614E+02	1.760684E+02	84.8743	-94.67	-2073.32	2027.64	
2519	19	6.250000E-02	2.057524E+03	1.104614E+02	-1.760684E+02	-5.1257	2073.32	94.67	2027.64	
2523	23	-6.300000E-02	-2.070316E+03	-3.827883E+01	-9.264811E+00	-89.7388	-38.24	-2070.36	2051.51	
2523	18	-6.300000E-02	2.070316E+03	3.827883E+01	9.264811E+00	0.2612	2070.36	38.24	2051.51	
2523	19	6.250000E-02	2.060323E+03	3.261142E+01	-1.972231E+01	-0.5572	2060.51	32.42	2044.50	
2523	22	6.250000E-02	-2.060323E+03	-3.261142E+01	1.972231E+01	89.4428	-32.42	-2060.51	2044.50	
2525	22	-6.300000E-02	2.045318E+03	1.139856E+02	1.589403E+02	4.6733	2058.31	100.99	2009.72	
2525	19	-6.300000E-02	-2.045318E+03	-1.139856E+02	-1.589403E+02	-85.3267	-100.99	-2058.31	2009.72	
2527	23	6.250000E-02	1.962423E+03	6.973883E+01	4.260245E+02	12.1182	2053.90	-21.73	2064.85	
2527	18	6.250000E-02	-1.962423E+03	-6.973883E+01	-4.260245E+02	-77.8818	21.73	-2053.90	2064.85	
2523	19	-6.300000E-02	-2.051120E+03	-3.803877E+01	1.113144E+01	89.6832	-37.98	-2051.18	2032.46	
2523	22	-6.300000E-02	2.051120E+03	3.803877E+01	-1.113144E+01	-0.3168	2051.18	37.98	2032.46	
2519	18	6.250000E-02	-2.036924E+03	-1.164148E+02	1.419185E+02	85.7965	-105.98	-2047.35	1996.47	
2519	23	6.250000E-02	2.036924E+03	1.164148E+02	-1.419185E+02	-4.2035	2047.35	105.98	1996.47	
2525	23	-6.300000E-02	-2.018269E+03	-1.106444E+02	-1.811160E+02	-84.6242	-93.60	-2035.31	1990.16	
2525	18	-6.300000E-02	2.018269E+03	1.106444E+02	1.811160E+02	5.3758	2035.31	93.60	1990.16	
2517	22	6.250000E-02	-1.945875E+03	-6.947814E+01	4.188664E+02	77.9706	19.78	-2035.13	2045.09	
2517	19	6.250000E-02	1.945875E+03	6.947814E+01	-4.188664E+02	-12.0294	2035.13	-19.78	2045.09	
2525	19	6.250000E-02	2.013274E+03	1.155652E+02	1.404964E+02	4.2113	2023.62	105.22	1973.11	
2525	22	6.250000E-02	-2.013274E+03	-1.155652E+02	-1.404964E+02	-85.7887	-105.22	-2023.62	1973.11	
2519	19	-6.300000E-02	-2.003301E+03	-1.079293E+02	1.779664E+02	84.6821	-91.36	-2019.87	1975.77	
2519	22	-6.300000E-02	2.003301E+03	1.079293E+02	-1.779664E+02	-5.3179	2019.87	91.36	1975.77	
2517	18	-6.300000E-02	1.904323E+03	6.904458E+01	-3.761917E+02	-11.1457	1978.44	-5.07	1980.98	
2517	23	-6.300000E-02	-1.904323E+03	-6.904458E+01	3.761917E+02	78.8543	5.07	-1978.44	1980.98	
2527	22	-6.300000E-02	1.874434E+03	6.831033E+01	3.726924E+02	11.2129	1948.32	-5.57	1951.11	
2527	19	-6.300000E-02	-1.874434E+03	-6.831033E+01	-3.726924E+02	-78.7871	5.57	-1948.32	1951.11	

TABLE 5.6 BACK PANEL PLATE STRESSES

DATABASE: static1.f06
 OUTPUT FILE: backpanel.out

ID	LOADID	FIBRE DISTANCE	STRESSES IN ELEMENT COORD SYSTEM			PRINCIPAL STRESSES (ZERO SHEAR)			VON MISES
			NORMAL-X	NORMAL-Y	SHEAR-XY	ANGLE	MAJOR	MINOR	
3029	23	4.250000E-02	-4.040086E+02	-1.061910E+03	-2.369214E+01	-2.0598	-403.16	-1062.76	929.27
3029	18	4.250000E-02	4.040086E+02	1.061910E+03	2.369214E+01	87.9402	1062.76	403.16	929.27
3029	18	-4.300000E-02	-4.676631E+02	-1.058232E+03	4.404631E+01	4.2420	-464.40	-1061.50	921.68
3029	23	-4.300000E-02	4.676631E+02	1.058232E+03	-4.404631E+01	-85.7580	1061.50	464.40	921.68
3029	19	-4.300000E-02	4.857493E+02	1.041842E+03	3.964668E+01	85.9424	1044.65	482.94	905.55
3029	22	-4.300000E-02	-4.857493E+02	-1.041842E+03	-3.964668E+01	-4.0576	-482.94	-1044.65	905.55
3029	15	-4.300000E-02	4.664764E+02	1.033477E+03	-4.309655E+01	-85.6782	1036.73	463.22	899.53
3029	10	-4.300000E-02	-4.664764E+02	-1.033477E+03	4.309655E+01	4.3218	-463.22	-1036.73	899.53
3029	19	4.250000E-02	-3.732946E+02	-1.028595E+03	6.409001E+01	5.5338	-367.09	-1034.80	908.69
3029	22	4.250000E-02	3.732946E+02	1.028595E+03	-6.409001E+01	-84.4662	1034.80	367.09	908.69
3029	15	4.250000E-02	-3.808056E+02	-1.029445E+03	-3.106194E+01	-2.7354	-379.32	-1030.93	903.13
3029	10	4.250000E-02	3.808056E+02	1.029445E+03	3.106194E+01	87.2646	1030.93	379.32	903.13
3029	11	-4.300000E-02	4.845626E+02	1.017087E+03	4.059644E+01	85.6655	1020.16	481.49	883.95
3029	14	-4.300000E-02	-4.845626E+02	-1.017087E+03	-4.059644E+01	-4.3345	-481.49	-1020.16	883.95
3029	11	4.250000E-02	-3.500916E+02	-9.961302E+02	5.672021E+01	4.9796	-345.15	-1001.07	880.77
3029	14	4.250000E-02	3.500916E+02	9.961302E+02	-5.672021E+01	-85.0204	1001.07	345.15	880.77
3029	7	4.250000E-02	-3.619400E+02	-9.502192E+02	-5.087375E+01	-4.9063	-357.57	-954.59	835.32
3029	2	4.250000E-02	3.619400E+02	9.502192E+02	5.087375E+01	85.0937	954.59	357.57	835.32
3029	7	-4.300000E-02	4.139736E+02	9.444072E+02	-6.112206E+01	-83.5111	951.36	407.02	826.76
3029	2	-4.300000E-02	-4.139736E+02	-9.444072E+02	6.112206E+01	6.4889	-407.02	-951.36	826.76
3029	3	-4.300000E-02	4.403448E+02	9.194551E+02	5.638237E+01	83.3779	926.00	433.80	802.47
3029	6	-4.300000E-02	-4.403448E+02	-9.194551E+02	-5.638237E+01	-6.6221	-433.80	-926.00	802.47
3029	6	4.250000E-02	3.168441E+02	8.996548E+02	-8.204169E+01	-82.1380	910.98	305.52	803.06

TABLE 5.7 BOTTLE RETENTION PLATE STRESSES

DATABASE: static1.f06
OUTPUT FILE: brp.out

ID	LOADID	FIBRE DISTANCE	STRESSES IN ELEMENT COORD SYSTEM			PRINCIPAL STRESSES (ZERO SHEAR)			VON MISES
			NORMAL-X	NORMAL-Y	SHEAR-XY	ANGLE	MAJOR	MINOR	
12698	23	6.250000E-02	-1.676101E+04	-1.364803E+04	7.694747E+03	50.7177	-7353.93	-23055.11	20397.86
12698	18	6.250000E-02	1.676101E+04	1.364803E+04	-7.694747E+03	-39.2823	23055.11	7353.93	20397.86
12698	15	6.250000E-02	-1.670514E+04	-1.364952E+04	7.653179E+03	50.6448	-7373.14	-22981.52	20324.06
12698	10	6.250000E-02	1.670514E+04	1.364952E+04	-7.653179E+03	-39.3552	22981.52	7373.14	20324.06
12698	7	6.250000E-02	-1.649723E+04	-1.363348E+04	7.626341E+03	50.3169	-7305.76	-22824.96	20189.08
12698	2	6.250000E-02	1.649723E+04	1.363348E+04	-7.626341E+03	-39.6831	22824.96	7305.76	20189.08
12698	15	-6.300000E-02	1.402029E+04	1.433417E+04	-7.681711E+03	-45.5852	21860.55	6493.92	19444.64
12698	10	-6.300000E-02	-1.402029E+04	-1.433417E+04	7.681711E+03	44.4148	-6493.92	-21860.55	19444.64
12698	23	-6.300000E-02	1.389798E+04	1.440636E+04	-7.688438E+03	-45.9468	21844.80	6459.53	19437.43
12698	18	-6.300000E-02	-1.389798E+04	-1.440636E+04	7.688438E+03	44.0532	-6459.53	-21844.80	19437.43
12698	7	-6.300000E-02	1.384977E+04	1.427380E+04	-7.674815E+03	-45.7912	21739.53	6384.04	19353.99
12698	2	-6.300000E-02	-1.384977E+04	-1.427380E+04	7.674815E+03	44.2088	-6384.04	-21739.53	19353.99
12698	19	6.250000E-02	-1.434152E+04	-1.258688E+04	7.683661E+03	48.2569	-5730.62	-21197.79	18992.36
12698	22	6.250000E-02	1.434152E+04	1.258688E+04	-7.683661E+03	-41.7431	21197.79	5730.62	18992.36
12698	11	6.250000E-02	-1.428565E+04	-1.258838E+04	7.642093E+03	48.1683	-5747.95	-21126.08	18918.74
12698	14	6.250000E-02	1.428565E+04	1.258838E+04	-7.642093E+03	-41.8317	21126.08	5747.95	18918.74
12652	24	-6.300000E-02	2.083328E+04	5.188658E+03	-1.443976E+03	-5.2294	20965.44	5056.50	18950.09
12652	17	-6.300000E-02	-2.083328E+04	-5.188658E+03	1.443976E+03	84.7706	-5056.50	-20965.44	18950.09
12652	8	-6.300000E-02	2.081469E+04	5.175246E+03	-1.404626E+03	-5.0916	20939.84	5050.09	18927.03
12652	1	-6.300000E-02	-2.081469E+04	-5.175246E+03	1.404626E+03	84.9084	-5050.09	-20939.84	18927.03
12652	16	-6.300000E-02	2.079030E+04	5.174520E+03	-1.407869E+03	-5.1107	20916.22	5048.61	18904.47
12652	9	-6.300000E-02	-2.079030E+04	-5.174520E+03	1.407869E+03	84.8893	-5048.61	-20916.22	18904.47

5.2 Beam Element Analysis

The MS for beam elements representing panel stiffeners, slide bars and internal components of the GDS are presented in Table 5.8. The MS for beam members are computed based on the von Mises stress. The following explains the algorithm used in the derivation of von Mises stress and MS for each beam element.

A customized FORTRAN program reads the beam element forces recovered from the MSC/NASTRAN static analysis and calculates the von Mises stress for the beam element based on its cross sectional properties. The forces applied to the beam element include axial (P_a), two shears (V_1 and V_2), two bending moments (M_1 and M_2), and torque (T).

Considering first the combination of the axial load and the bending moments, the maximum tensile or compressive stress is calculated using the following equation:

$$S = \frac{Axial\ Load}{A} + \frac{M_i C_i}{I_i}$$

Where :

A = cross sectional area

M_i = moment about the i - axis

C_i = distance from centroid to outermost fiber in the i - direction

I_i = moment of inertia about the i - axis

Next, combining shear forces and torsion, the maximum shear stress is calculated using the following equation:

$$t = \frac{Torsion}{q} + \frac{V_i Q_i}{I_i B_i}$$

Where:

q = constant relating torque to shear

V_i = shear component in i - direction

Q_i = first moment of the area of the beam above or below the neutral axis
in the i - direction

b_i = thickness of the beam in the i - direction

I_i = moment of inertia about the i - axis

The von Mises stress is calculated by first computing the principal stresses as following:

$$\sigma_1, \sigma_2 = \frac{\sigma}{2} \pm \sqrt{\frac{\sigma^2}{4} + t^2}$$

and subsequently calculating the von Mises stress,

$$Von\ Mises = \sqrt{\sigma_1^2 - \sigma_1\sigma_2 + \sigma_2^2}$$

The MS are then calculated from the equation:

$$MS = \frac{F_t}{FS * \sigma_v} - 1$$

where,

F_t = Ultimate or yield allowable stress

FS = Factor of safety, 2.0 for ultimate and 1.25 for yield

The largest beam stress in the GDS drawer is on the bottle retention plate. The stress is 19223.42 psi, which gives a MS of:

$$MS_{ult} := \frac{68000}{2.0 \cdot 19223.42} - 1 \quad MS_{ult} = 0.769$$

$$MS_{yld} := \frac{57000}{1.25 \cdot 19223.42} - 1 \quad MS_{yld} = 1.372$$

MAXIMUM beam stresses with the appropriate MS can be found in Table 5.8.

TABLE 5.8 GDS MAXIMUM BEAM STRESSES

Bottom Panel Stiffeners

Aluminum 7075-T7351

ALLOWABLE TENSION ULTIMATE IS 68000.00
 ALLOWABLE TENSION YIELD IS 57000.00
 FACTOR OF SAFETY FOR YIELD IS 1.25
 FACTOR OF SAFETY FOR ULTIMATE IS 2.0

ELEMENT ID	LOAD CASE	TENSILE STRESS	SHEAR STRESS	PRINCIPAL STRESS	VONMISES STRESS	MINIMUM M.S. YIELD	MINIMUM M.S. ULTIMATE
2140	20	1408.51	78.56	1412.88	1415.07	31.22	23.03
2143	24	1381.68	76.76	1385.93	1388.06	31.85	23.49
2142	18	1351.96	24.75	1352.41	1352.64	32.71	24.14
2141	24	1329.67	20.76	1329.99	1330.15	33.28	24.56
2137	18	1289.88	129.77	1302.80	1309.31	33.83	24.97
2134	22	1272.89	126.87	1285.42	1291.72	34.30	25.32
2136	18	1205.93	33.30	1206.85	1207.31	36.77	27.16
2135	22	1192.07	33.12	1192.99	1193.45	37.21	27.49
2146	20	1130.54	174.40	1156.83	1170.20	37.97	28.05
2149	24	1090.16	172.03	1116.66	1130.14	39.35	29.08
2148	20	1032.05	36.66	1033.35	1034.00	43.10	31.88
2139	20	1012.56	82.30	1019.20	1022.54	43.59	32.25
2147	24	1010.23	39.16	1011.74	1012.50	44.04	32.58
2144	24	985.80	81.18	992.44	995.78	44.79	33.14
2131	18	870.90	199.80	914.55	937.14	47.66	35.28
2128	22	866.27	196.42	908.72	930.68	48.00	35.53
2133	19	879.32	139.45	900.90	911.89	49.01	36.29
2138	18	861.73	142.84	884.79	896.54	49.86	36.92
2114	20	799.00	120.76	816.86	825.93	54.21	40.17

1

Front Panel Stiffeners

Aluminum 7075-T7351

ALLOWABLE TENSION ULTIMATE IS 68000.00
 ALLOWABLE TENSION YIELD IS 57000.00
 FACTOR OF SAFETY FOR YIELD IS 1.25
 FACTOR OF SAFETY FOR ULTIMATE IS 2.0

ELEMENT ID	LOAD CASE	TENSILE STRESS	SHEAR STRESS	PRINCIPAL STRESS	VONMISES STRESS	MINIMUM M.S. YIELD	MINIMUM M.S. ULTIMATE
11060	5	11793.24	6570.50	14725.07	16388.86	1.78	1.07
11019	1	11650.17	6297.80	14403.77	15959.74	1.86	1.13
11056	5	8980.52	2938.27	9856.44	10322.30	3.42	2.29
11023	1	8849.67	2673.25	9594.50	9987.76	3.57	2.40
11020	7	7188.84	3802.22	8826.70	9749.36	3.68	2.49
11059	3	6653.83	3836.65	8405.13	9403.89	3.85	2.62
11055	5	9155.11	1067.36	9277.90	9339.90	3.88	2.64
11024	1	9117.70	1054.71	9238.11	9298.91	3.90	2.66
11057	5	7115.42	3092.22	8271.42	8905.87	4.12	2.82
11022	1	7168.43	2862.22	8171.04	8715.70	4.23	2.90
11058	5	5011.84	3069.81	6468.67	7306.83	5.24	3.65
11021	1	5209.27	2907.18	6507.95	7245.11	5.29	3.69
11025	1	6647.33	1007.54	6796.69	6872.59	5.64	3.95
11054	5	6581.21	1038.78	6741.27	6822.72	5.68	3.98
11026	1	5594.13	949.45	5750.88	5830.84	6.82	4.83

11018	10	5376.50	870.80	5514.02	5584.05	7.17	5.09
11053	5	5303.03	969.75	5474.80	5562.67	7.20	5.11
11027	2	5040.76	1126.76	5281.16	5405.37	7.44	5.29
11061	14	5107.98	689.61	5199.44	5245.77	7.69	5.48
11028	2	4380.80	1126.89	4653.68	4795.94	8.51	6.09
11052	6	4163.94	1083.41	4428.97	4567.25	8.98	6.44
11051	6	3295.96	1027.91	3590.25	3746.08	11.17	8.08
11013	10	3493.26	289.54	3517.10	3529.08	11.92	8.63
11017	10	3356.75	491.55	3427.25	3463.04	12.17	8.82
11066	14	3389.23	361.95	3427.45	3446.72	12.23	8.86

1

Back Panel Stiffeners

Aluminum 6061-T6

ALLOWABLE TENSION ULTIMATE IS 42000.00
 ALLOWABLE TENSION YIELD IS 35000.00
 FACTOR OF SAFETY FOR YIELD IS 1.25
 FACTOR OF SAFETY FOR ULTIMATE IS 2.0

ELEMENT ID	LOAD CASE	TENSILE STRESS	SHEAR STRESS	PRINCIPAL STRESS	VONMISES STRESS	MINIMUM M.S. YIELD	MINIMUM M.S. ULTIMATE
3098	18	2438.59	1143.68	2891.03	3141.77	7.91	5.68
3077	4	2652.58	650.55	2803.54	2881.98	8.72	6.29
3088	8	2543.96	619.88	2686.97	2761.25	9.14	6.61
3085	16	1867.91	143.96	1878.94	1884.48	13.86	10.14
3118	18	1666.22	170.06	1683.40	1692.05	15.55	11.41
3102	10	1288.09	580.93	1511.38	1634.50	16.13	11.85
3079	16	1511.62	187.05	1534.42	1545.95	17.11	12.58
3084	12	1518.74	55.94	1520.80	1521.83	17.40	12.80
3086	16	1484.60	175.44	1505.05	1515.38	17.48	12.86
3080	16	1484.81	118.43	1494.20	1498.91	17.68	13.01
3083	12	1490.17	42.86	1491.41	1492.02	17.77	13.07
3076	7	1250.56	130.09	1263.95	1270.70	21.04	15.53
3081	12	1246.00	89.91	1252.45	1255.69	21.30	15.72
3082	12	1248.41	49.63	1250.38	1251.37	21.38	15.78
3089	3	1233.00	108.89	1242.55	1247.35	21.45	15.84
3078	5	1109.57	134.07	1125.54	1133.61	23.70	17.52
3087	1	1067.20	113.26	1079.08	1085.08	24.80	18.35
3075	5	885.11	345.29	1003.87	1068.22	25.21	18.66

1

Back Panel Stiffeners

Aluminum 6061-T6

ALLOWABLE TENSION ULTIMATE IS 42000.00
 ALLOWABLE TENSION YIELD IS 35000.00
 FACTOR OF SAFETY FOR YIELD IS 1.25
 FACTOR OF SAFETY FOR ULTIMATE IS 2.0

ELEMENT ID	LOAD CASE	TENSILE STRESS	SHEAR STRESS	PRINCIPAL STRESS	VONMISES STRESS	MINIMUM M.S. YIELD	MINIMUM M.S. ULTIMATE
3123	12	191.57	135.86	262.02	303.44	91.28	68.21
3120	24	223.53	27.93	226.96	228.70	121.43	90.82
3122	10	97.18	111.84	170.53	216.73	128.20	95.90
3121	12	188.45	59.00	205.40	214.38	129.61	96.96
3119	13	94.73	45.91	113.33	123.68	225.39	168.79

1

Left (PBAR 101) Panel Stiffeners

Aluminum 7075-T7351

ALLOWABLE TENSION ULTIMATE IS 68000.00
 ALLOWABLE TENSION YIELD IS 57000.00
 FACTOR OF SAFETY FOR YIELD IS 1.25
 FACTOR OF SAFETY FOR ULTIMATE IS 2.0

ELEMENT ID	LOAD CASE	TENSILE STRESS	SHEAR STRESS	PRINCIPAL STRESS	VONMISES STRESS	MINIMUM M.S. YIELD	MINIMUM M.S. ULTIMATE
1105	21	5664.27	329.93	5683.42	5693.02	7.01	4.97
1118	4	5510.12	242.77	5520.80	5526.14	7.25	5.15
1115	6	4907.18	228.46	4917.79	4923.11	8.26	5.91
1103	24	4847.09	464.11	4891.13	4913.29	8.28	5.92
1106	22	4776.95	460.33	4820.90	4843.03	8.42	6.02
1109	20	4797.87	278.05	4813.93	4821.98	8.46	6.05
1124	4	4246.40	92.68	4248.42	4249.43	9.73	7.00
1119	4	3817.37	286.75	3838.79	3849.54	10.85	7.83
1110	20	3416.94	377.24	3458.09	3478.85	12.11	8.77
1117	23	3421.24	190.15	3431.77	3437.05	12.27	8.89
1121	6	3160.45	163.67	3168.90	3173.14	13.37	9.71
1104	21	2746.64	422.03	2810.02	2842.24	15.04	10.96
1107	22	2801.57	211.20	2817.40	2825.35	15.14	11.03
1116	6	2665.08	141.34	2672.56	2676.31	16.04	11.70
1125	4	2523.13	107.33	2527.69	2529.97	17.02	12.44
1112	4	2458.32	80.28	2460.94	2462.25	17.52	12.81
1108	19	2408.89	52.38	2410.03	2410.60	17.92	13.10
1126	5	1992.02	156.53	2004.25	2010.39	21.68	15.91
1123	3	1965.91	58.56	1967.66	1968.53	22.16	16.27
1122	6	1919.31	65.11	1921.51	1922.62	22.72	16.68
1111	3	1757.22	405.42	1846.25	1892.33	23.10	16.97
1113	4	1523.14	458.89	1650.71	1718.06	25.54	18.79
1120	23	1639.42	66.70	1642.13	1643.49	26.75	19.69
1114	4	1263.87	532.60	1458.37	1564.72	28.14	20.73

1

Left (PBAR 102) Panel Stiffeners

Aluminum 7075-T7351

ALLOWABLE TENSION ULTIMATE IS 68000.00
 ALLOWABLE TENSION YIELD IS 57000.00
 FACTOR OF SAFETY FOR YIELD IS 1.25
 FACTOR OF SAFETY FOR ULTIMATE IS 2.0

ELEMENT ID	LOAD CASE	TENSILE STRESS	SHEAR STRESS	PRINCIPAL STRESS	VONMISES STRESS	MINIMUM M.S. YIELD	MINIMUM M.S. ULTIMATE
1127	7	5572.12	2745.56	6697.61	7325.49	5.22	3.64
1132	8	6822.67	784.93	6911.81	6956.81	5.55	3.89
1128	15	2930.15	483.26	3007.80	3047.36	13.96	10.16
1129	2	1463.08	279.74	1514.74	1541.22	28.59	21.06
1131	5	1233.19	171.47	1256.58	1268.44	34.95	25.80
1130	11	1157.34	109.50	1167.61	1172.77	37.88	27.99

1

Left (PBAR 103) Panel Stiffeners

Aluminum 7075-T7351

ALLOWABLE TENSION ULTIMATE IS 68000.00

ALLOWABLE TENSION YIELD IS 57000.00
 FACTOR OF SAFETY FOR YIELD IS 1.25
 FACTOR OF SAFETY FOR ULTIMATE IS 2.0

ELEMENT ID	LOAD CASE	TENSILE STRESS	SHEAR STRESS	PRINCIPAL STRESS	VONMISES STRESS	MINIMUM M.S. YIELD	MINIMUM M.S. ULTIMATE
1138	5	6111.50	413.95	6139.41	6153.42	6.41	4.53
1135	5	2280.16	529.14	2396.97	2457.46	17.56	12.84
1136	4	1904.88	329.13	1960.15	1988.35	21.93	16.10
1137	7	1251.28	114.41	1261.66	1266.88	34.99	25.84
1133	21	395.69	73.42	408.88	415.63	108.71	80.80
1134	23	248.92	38.73	254.81	257.80	175.88	130.89

1

Left (PBAR 104) Panel Stiffeners

Aluminum 7075-T7351

ALLOWABLE TENSION ULTIMATE IS 68000.00
 ALLOWABLE TENSION YIELD IS 57000.00
 FACTOR OF SAFETY FOR YIELD IS 1.25
 FACTOR OF SAFETY FOR ULTIMATE IS 2.0

ELEMENT ID	LOAD CASE	TENSILE STRESS	SHEAR STRESS	PRINCIPAL STRESS	VONMISES STRESS	MINIMUM M.S. YIELD	MINIMUM M.S. ULTIMATE
1139	1	2774.77	222.01	2792.42	2801.29	15.28	11.14
1142	17	2036.31	612.29	2206.24	2295.93	18.86	13.81
1140	1	2133.42	100.92	2138.19	2140.57	20.30	14.88
1148	6	1616.76	712.35	1885.84	2033.77	21.42	15.72
1145	22	1608.42	609.31	1813.17	1923.74	22.70	16.67
1151	3	1184.62	455.74	1339.66	1423.52	31.03	22.88
1141	1	1203.64	147.12	1221.36	1230.32	36.06	26.64
1143	1	816.62	132.07	837.44	848.05	52.77	39.09
1147	6	750.85	181.42	792.38	813.94	55.02	40.77
1150	6	713.67	201.83	766.79	794.68	56.38	41.78
1144	1	776.43	84.25	785.46	790.02	56.72	42.04
1146	9	487.94	102.88	508.74	519.45	86.78	64.45
1152	2	355.76	119.20	392.01	411.33	109.86	81.66
1149	2	348.44	15.85	349.16	349.52	129.47	96.28
1153	19	287.37	90.75	313.63	327.55	138.22	102.80
1154	17	203.88	106.89	249.65	275.40	164.58	122.46

1

Left (PBAR 105) Panel Stiffeners

Aluminum 7075-T7351

ALLOWABLE TENSION ULTIMATE IS 68000.00
 ALLOWABLE TENSION YIELD IS 57000.00
 FACTOR OF SAFETY FOR YIELD IS 1.25
 FACTOR OF SAFETY FOR ULTIMATE IS 2.0

ELEMENT ID	LOAD CASE	TENSILE STRESS	SHEAR STRESS	PRINCIPAL STRESS	VONMISES STRESS	MINIMUM M.S. YIELD	MINIMUM M.S. ULTIMATE
1171	5	2281.75	551.50	2408.06	2473.63	17.43	12.74
1156	2	2303.61	210.06	2322.61	2332.16	18.55	13.58
1168	5	1266.58	433.70	1400.85	1472.59	29.97	22.09
1159	6	1146.76	453.73	1304.57	1390.21	31.80	23.46
1170	5	954.20	423.92	1115.32	1204.00	36.87	27.24
1157	8	1049.16	306.67	1132.22	1175.95	37.78	27.91
1158	6	936.42	350.29	1052.95	1115.79	39.87	29.47

1169	5	968.11	290.26	1048.47	1090.87	40.80	30.17
1165	5	942.39	208.56	986.49	1009.26	44.18	32.69
1160	6	642.62	213.35	707.00	741.29	60.51	44.87
1161	6	595.26	154.41	632.93	652.58	68.88	51.10
1162	5	533.22	140.74	568.09	586.30	76.78	56.99
1163	5	459.58	147.19	502.68	525.56	85.76	63.69
1166	5	430.41	105.17	454.74	467.37	96.57	71.75
1167	5	388.94	107.54	416.69	431.24	104.74	77.84
1164	5	387.58	21.81	388.80	389.41	116.10	86.31

1

Left (PBAR 106) Panel Stiffeners

Aluminum 7075-T7351

ALLOWABLE TENSION ULTIMATE IS 68000.00

ALLOWABLE TENSION YIELD IS 57000.00

FACTOR OF SAFETY FOR YIELD IS 1.25

FACTOR OF SAFETY FOR ULTIMATE IS 2.0

ELEMENT ID	LOAD CASE	TENSILE STRESS	SHEAR STRESS	PRINCIPAL STRESS	VONMISES STRESS	MINIMUM M.S. YIELD	MINIMUM M.S. ULTIMATE
1173	8	6871.40	1160.11	7061.98	7159.17	5.37	3.75
1188	3	4098.86	1092.02	4371.64	4514.22	9.10	6.53
1174	4	2528.94	555.32	2645.51	2705.68	15.85	11.57
1187	3	1628.92	487.17	1763.50	1834.49	23.86	17.53
1175	8	1349.56	436.08	1478.21	1546.55	28.49	20.98
1176	6	1116.67	431.21	1263.80	1343.42	32.94	24.31
1185	5	1036.54	419.37	1184.96	1265.72	35.03	25.86
1182	21	989.40	309.50	1078.24	1125.29	39.52	29.21
1186	5	674.55	342.43	817.91	898.22	49.77	36.85
1179	3	770.38	229.91	833.77	867.21	51.58	38.21
1177	8	765.13	229.23	828.55	862.01	51.90	38.44
1184	5	555.07	150.42	593.21	613.17	73.37	54.45
1180	7	534.15	141.15	569.15	587.44	76.63	56.88
1178	5	480.30	190.00	546.37	582.23	77.32	57.40
1181	17	448.24	99.14	469.18	480.00	94.00	69.83
1183	5	405.10	126.24	441.22	460.35	98.06	72.86

1

Left (PBAR 107) Panel, slide-support beams

Aluminum 7075-T7351

ALLOWABLE TENSION ULTIMATE IS 68000.00

ALLOWABLE TENSION YIELD IS 57000.00

FACTOR OF SAFETY FOR YIELD IS 1.25

FACTOR OF SAFETY FOR ULTIMATE IS 2.0

ELEMENT ID	LOAD CASE	TENSILE STRESS	SHEAR STRESS	PRINCIPAL STRESS	VONMISES STRESS	MINIMUM M.S. YIELD	MINIMUM M.S. ULTIMATE
1193	21	5504.59	3949.61	7566.29	8780.59	4.19	2.87
1198	20	4178.86	2092.24	5046.32	5531.30	7.24	5.15
1204	4	4338.46	1297.39	4696.84	4885.89	8.33	5.96
1192	17	3057.94	649.95	3190.35	3258.57	12.99	9.43
1194	21	2775.37	880.17	3030.97	3166.51	13.40	9.74
1202	20	2019.68	1286.13	2645.05	3006.91	14.17	10.31
1199	20	2246.06	1114.98	2705.55	2962.15	14.39	10.48
1203	21	2093.50	677.57	2293.66	2400.01	18.00	13.17
1201	21	1892.90	689.85	2117.63	2238.47	19.37	14.19
1196	20	1527.46	897.61	1942.28	2179.51	19.92	14.60
1195	21	1698.75	501.25	1835.63	1907.75	22.90	16.82
1191	6	1441.42	265.39	1488.73	1512.93	29.14	21.47

1205	4	1440.73	263.29	1487.34	1511.18	29.18	21.50
1190	6	816.31	113.24	831.73	839.55	53.32	39.50
1197	21	736.01	195.08	784.51	809.86	55.31	40.98
1200	23	419.47	95.86	440.34	451.14	100.08	74.36

1

Right (PBAR 101) Panel Stiffeners

Aluminum 7075-T7351

ALLOWABLE TENSION ULTIMATE IS 68000.00

ALLOWABLE TENSION YIELD IS 57000.00

FACTOR OF SAFETY FOR YIELD IS 1.25

FACTOR OF SAFETY FOR ULTIMATE IS 2.0

ELEMENT ID	LOAD CASE	TENSILE STRESS	SHEAR STRESS	PRINCIPAL STRESS	VONMISES STRESS	MINIMUM M.S. YIELD	MINIMUM M.S. ULTIMATE
1605	17	5734.39	319.36	5752.12	5761.00	6.92	4.90
1618	8	5393.06	249.35	5404.56	5410.32	7.43	5.28
1603	20	4938.22	481.79	4984.78	5008.23	8.11	5.79
1615	2	4700.10	213.14	4709.74	4714.57	8.67	6.21
1606	18	4649.69	437.12	4690.42	4710.92	8.68	6.22
1609	24	4664.93	283.35	4682.07	4690.67	8.72	6.25
1624	8	4085.98	95.34	4088.20	4089.32	10.15	7.31
1619	8	3693.47	294.56	3716.81	3728.54	11.23	8.12
1610	24	3348.08	370.83	3388.66	3409.13	12.38	8.97
1617	19	3291.28	180.30	3301.13	3306.06	12.79	9.28
1621	2	2956.07	156.10	2964.29	2968.41	14.36	10.45
1604	17	2708.95	429.92	2775.54	2809.43	15.23	11.10
1607	18	2737.53	195.67	2751.45	2758.43	15.53	11.33
1616	2	2591.01	133.69	2597.89	2601.34	16.53	12.07
1625	8	2429.94	102.56	2434.26	2436.43	17.72	12.95
1612	8	2327.07	79.08	2329.75	2331.10	18.56	13.59
1608	23	2233.06	53.24	2234.33	2234.96	19.40	14.21
1626	1	2007.09	161.37	2019.98	2026.46	21.50	15.78
1611	3	1825.86	252.45	1860.12	1877.49	23.29	17.11
1622	2	1817.52	68.27	1820.08	1821.36	24.04	17.67
1623	19	1794.28	100.90	1799.93	1802.77	24.29	17.86
1613	8	1478.28	456.10	1607.68	1676.13	26.21	19.28
1620	19	1598.14	59.50	1600.35	1601.46	27.47	20.23
1614	8	1210.28	524.35	1405.85	1513.14	29.14	21.47

1

Right (PBAR 102) Panel Stiffeners

Aluminum 7075-T7351

ALLOWABLE TENSION ULTIMATE IS 68000.00

ALLOWABLE TENSION YIELD IS 57000.00

FACTOR OF SAFETY FOR YIELD IS 1.25

FACTOR OF SAFETY FOR ULTIMATE IS 2.0

ELEMENT ID	LOAD CASE	TENSILE STRESS	SHEAR STRESS	PRINCIPAL STRESS	VONMISES STRESS	MINIMUM M.S. YIELD	MINIMUM M.S. ULTIMATE
1627	3	5585.98	2828.24	6767.88	7429.67	5.14	3.58
1632	4	6669.80	734.34	6749.70	6790.00	5.72	4.01
1628	11	3158.63	529.96	3245.18	3289.30	12.86	9.34
1629	6	1728.48	329.62	1789.21	1820.33	24.05	17.68
1631	1	1250.19	174.34	1274.05	1286.14	34.45	25.44
1630	15	1139.99	126.78	1153.92	1160.94	38.28	28.29

1

Right (PBAR 103) Panel Stiffeners

Aluminum 7075-T7351

ALLOWABLE TENSION ULTIMATE IS 68000.00
 ALLOWABLE TENSION YIELD IS 57000.00
 FACTOR OF SAFETY FOR YIELD IS 1.25
 FACTOR OF SAFETY FOR ULTIMATE IS 2.0

ELEMENT ID	LOAD CASE	TENSILE STRESS	SHEAR STRESS	PRINCIPAL STRESS	VONMISES STRESS	MINIMUM M.S. YIELD	MINIMUM M.S. ULTIMATE
1638	1	5934.58	414.41	5963.38	5977.83	6.63	4.69
1635	1	2107.65	486.45	2214.51	2269.82	19.09	13.98
1636	8	1852.37	313.10	1903.86	1930.12	22.63	16.62
1637	3	1215.70	112.66	1226.05	1231.26	36.04	26.61
1633	17	395.64	73.80	408.95	415.77	108.68	80.78
1634	19	228.30	41.73	235.69	239.47	189.42	140.98

1

Right (PBAR 104) Panel Stiffeners

Aluminum 7075-T7351

ALLOWABLE TENSION ULTIMATE IS 68000.00
 ALLOWABLE TENSION YIELD IS 57000.00
 FACTOR OF SAFETY FOR YIELD IS 1.25
 FACTOR OF SAFETY FOR ULTIMATE IS 2.0

ELEMENT ID	LOAD CASE	TENSILE STRESS	SHEAR STRESS	PRINCIPAL STRESS	VONMISES STRESS	MINIMUM M.S. YIELD	MINIMUM M.S. ULTIMATE
1639	5	2742.00	222.85	2760.00	2769.04	15.47	11.28
1642	21	2075.45	623.90	2248.56	2339.93	18.49	13.53
1640	5	2115.07	99.53	2119.74	2122.08	20.49	15.02
1648	7	1544.16	676.77	1798.78	1938.68	22.52	16.54
1645	18	1556.12	594.14	1757.03	1865.62	23.44	17.22
1651	7	1120.64	424.09	1263.04	1339.92	33.03	24.37
1641	5	1223.42	151.37	1241.87	1251.20	35.45	26.17
1643	5	805.86	131.86	826.89	837.60	53.44	39.59
1644	5	775.48	78.29	783.30	787.24	56.92	42.19
1647	2	703.28	171.96	743.08	763.75	58.71	43.52
1650	2	666.81	191.76	718.02	744.95	60.21	44.64
1646	13	498.37	102.85	518.76	529.25	85.16	63.24
1652	6	345.92	114.57	380.42	398.80	113.34	84.26
1649	6	347.44	16.90	348.26	348.67	129.78	96.51
1653	23	282.63	96.74	312.57	328.56	137.79	102.48
1654	21	209.31	104.93	252.85	277.20	163.50	121.66

1

Right (PBAR 105) Panel Stiffeners

Aluminum 7075-T7351

ALLOWABLE TENSION ULTIMATE IS 68000.00
 ALLOWABLE TENSION YIELD IS 57000.00
 FACTOR OF SAFETY FOR YIELD IS 1.25
 FACTOR OF SAFETY FOR ULTIMATE IS 2.0

ELEMENT ID	LOAD CASE	TENSILE STRESS	SHEAR STRESS	PRINCIPAL STRESS	VONMISES STRESS	MINIMUM M.S. YIELD	MINIMUM M.S. ULTIMATE
1671	2	2259.67	571.89	2396.17	2467.24	17.48	12.78

1656	6	2330.96	200.57	2348.09	2356.71	18.35	13.43
1668	1	1235.11	422.18	1365.63	1435.35	30.77	22.69
1659	2	1118.55	443.16	1272.84	1356.59	32.61	24.06
1670	2	1006.12	357.76	1120.36	1181.63	37.59	27.77
1657	4	1028.61	302.93	1111.20	1154.70	38.49	28.44
1658	4	970.92	296.52	1054.31	1098.38	40.52	29.95
1669	1	925.22	279.28	1002.99	1044.04	42.68	31.57
1665	1	907.94	203.70	951.54	974.08	45.81	33.90
1660	2	620.26	205.76	682.31	715.36	62.74	46.53
1661	2	569.44	147.20	605.24	623.91	72.09	53.50
1662	1	519.44	139.27	554.42	572.72	78.62	58.37
1663	1	452.36	143.92	494.26	516.49	87.29	64.83
1666	1	415.80	104.02	440.37	453.16	99.63	74.03
1667	1	374.85	105.27	402.39	416.85	108.39	80.56
1664	1	358.32	20.00	359.43	359.99	125.67	93.45

1

Right (PBAR 106) Panel Stiffeners

Aluminum 7075-T7351

ALLOWABLE TENSION ULTIMATE IS 68000.00
 ALLOWABLE TENSION YIELD IS 57000.00
 FACTOR OF SAFETY FOR YIELD IS 1.25
 FACTOR OF SAFETY FOR ULTIMATE IS 2.0

ELEMENT ID	LOAD CASE	TENSILE STRESS	SHEAR STRESS	PRINCIPAL STRESS	VONMISES STRESS	MINIMUM M.S. YIELD	MINIMUM M.S. ULTIMATE
1673	4	6693.62	1139.34	6882.23	6978.45	5.53	3.87
1688	7	4109.77	1086.99	4379.56	4520.50	9.09	6.52
1674	8	2490.09	542.89	2603.30	2661.72	16.13	11.77
1687	7	1661.42	483.20	1791.73	1860.31	23.51	17.28
1675	4	1317.07	429.46	1444.73	1512.60	29.15	21.48
1676	2	1098.99	425.47	1244.46	1323.20	33.46	24.70
1685	1	1032.71	419.04	1181.34	1262.24	35.13	25.94
1682	17	983.75	310.28	1073.44	1120.97	39.68	29.33
1686	7	694.84	310.97	813.69	879.15	50.87	37.67
1679	7	770.86	232.38	835.49	869.61	51.44	38.10
1677	4	739.93	224.98	802.96	836.26	53.53	39.66
1680	3	543.39	141.87	578.20	596.37	75.46	56.01
1684	1	510.49	143.20	547.92	567.56	79.34	58.91
1678	1	445.13	180.06	508.84	543.51	82.90	61.56
1681	21	436.37	96.56	456.78	467.32	96.58	71.76
1683	1	379.23	123.53	415.92	435.43	103.72	77.08

1

Right (PBAR 107) Panel, slide-support beams

Aluminum 7075-T7351

ALLOWABLE TENSION ULTIMATE IS 68000.00
 ALLOWABLE TENSION YIELD IS 57000.00
 FACTOR OF SAFETY FOR YIELD IS 1.25
 FACTOR OF SAFETY FOR ULTIMATE IS 2.0

ELEMENT ID	LOAD CASE	TENSILE STRESS	SHEAR STRESS	PRINCIPAL STRESS	VONMISES STRESS	MINIMUM M.S. YIELD	MINIMUM M.S. ULTIMATE
1693	17	6016.07	4038.59	8043.76	9226.26	3.94	2.69
1698	24	4201.15	2091.47	5064.80	5547.28	7.22	5.13
1704	8	4121.84	1286.07	4490.19	4685.24	8.73	6.26
1692	21	2905.48	599.91	3024.47	3085.69	13.78	10.02
1702	24	2005.30	1273.75	2623.68	2981.36	14.30	10.40
1699	24	2238.83	1106.35	2693.30	2946.93	14.47	10.54

1694	17	2525.70	838.14	2778.52	2913.17	14.65	10.67
1703	17	2145.51	682.90	2344.43	2449.95	17.61	12.88
1701	17	1866.43	682.75	2089.52	2209.53	19.64	14.39
1696	24	1495.99	889.52	1910.21	2147.49	20.23	14.83
1695	17	1713.88	495.16	1846.66	1916.50	22.79	16.74
1691	2	1401.84	258.53	1447.99	1471.62	29.99	22.10
1705	8	1378.99	262.32	1427.21	1451.91	30.41	22.42
1690	9	738.76	198.79	788.85	815.06	54.95	40.71
1697	17	735.59	193.39	783.34	808.27	55.42	41.07
1700	19	414.75	91.03	433.84	443.70	101.77	75.63

1

Top (PBAR 1 & 219) Panel Stiffeners

Aluminum 6061-T6

ALLOWABLE TENSION ULTIMATE IS 42000.00
 ALLOWABLE TENSION YIELD IS 35000.00
 FACTOR OF SAFETY FOR YIELD IS 1.25
 FACTOR OF SAFETY FOR ULTIMATE IS 2.0

ELEMENT ID	LOAD CASE	TENSILE STRESS	SHEAR STRESS	PRINCIPAL STRESS	VONMISES STRESS	MINIMUM M.S. YIELD	MINIMUM M.S. ULTIMATE
2666	23	3183.38	246.95	3202.42	3211.98	7.72	5.54
2662	23	3178.09	229.96	3194.64	3202.95	7.74	5.56
2665	23	2995.23	81.17	2997.43	2998.53	8.34	6.00
2663	23	2995.52	64.41	2996.91	2997.60	8.34	6.01
2664	23	2915.99	11.63	2916.04	2916.06	8.60	6.20
2661	23	2524.12	322.36	2564.64	2585.14	9.83	7.12
2667	19	2502.57	319.72	2542.77	2563.11	9.92	7.19
2659	23	2541.91	175.40	2553.95	2560.00	9.94	7.20
2655	23	2525.45	170.71	2536.94	2542.70	10.01	7.26
2657	23	2339.02	3.45	2339.03	2339.03	10.97	7.98
2656	17	2164.75	58.15	2166.31	2167.10	11.92	8.69
2658	23	2147.19	75.63	2149.85	2151.18	12.02	8.76
2654	23	2112.67	183.83	2128.55	2136.53	12.11	8.83
2660	23	2098.86	186.67	2115.34	2123.62	12.19	8.89
2652	23	2018.98	157.73	2031.22	2037.38	12.74	9.31
2648	19	1990.26	151.97	2001.80	2007.59	12.95	9.46
2651	23	1939.27	48.31	1940.47	1941.07	13.43	9.82
2649	19	1929.66	45.56	1930.74	1931.28	13.50	9.87
2650	23	1864.59	7.74	1864.63	1864.64	14.02	10.26
2645	19	1668.19	103.63	1674.61	1677.82	15.69	11.52
2641	23	1656.69	102.94	1663.06	1666.26	15.80	11.60
2642	23	1608.69	76.34	1612.30	1614.11	16.35	12.01
2644	19	1606.03	77.48	1609.76	1611.63	16.37	12.03
2653	23	1559.29	197.24	1583.86	1596.28	16.54	12.16
2647	23	1555.14	195.75	1579.40	1591.67	16.59	12.19
2643	23	1514.84	39.65	1515.88	1516.40	17.46	12.85
2646	19	1296.56	149.36	1313.54	1322.12	20.18	14.88
2640	23	1295.73	149.12	1312.67	1321.22	20.19	14.89

1

Top (PBAR 217) Panel Stiffeners

Aluminum 6061-T6

ALLOWABLE TENSION ULTIMATE IS 42000.00
 ALLOWABLE TENSION YIELD IS 35000.00
 FACTOR OF SAFETY FOR YIELD IS 1.25
 FACTOR OF SAFETY FOR ULTIMATE IS 2.0

ELEMENT ID	LOAD CASE	TENSILE STRESS	SHEAR STRESS	PRINCIPAL STRESS	VONMISES STRESS	MINIMUM M.S. YIELD	MINIMUM M.S. ULTIMATE
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2638	24	1101.95	149.95	1121.99	1132.14	23.73	17.55
2627	20	1099.45	154.37	1120.71	1131.49	23.75	17.56
2625	18	726.17	184.13	770.19	793.12	34.30	25.48
2636	22	715.38	181.60	758.84	781.47	34.83	25.87
2623	23	659.12	146.40	690.17	706.21	38.65	28.74
2634	19	653.49	143.56	683.64	699.20	39.05	29.03
2621	23	512.04	159.37	557.59	581.71	47.13	35.10
2632	19	511.21	158.47	556.35	580.24	47.26	35.19
2639	7	383.44	234.56	494.66	558.64	49.12	36.59
2628	3	375.17	232.44	486.27	550.30	49.88	37.16
2635	19	464.04	69.72	474.29	479.50	57.39	42.80
2624	23	463.84	67.35	473.42	478.28	57.54	42.91
2620	1	442.08	82.50	456.98	464.61	59.27	44.20
2631	5	435.04	78.44	448.75	455.75	60.44	45.08
2619	1	366.11	154.06	422.31	453.03	60.81	45.35
2630	5	362.67	151.84	417.85	447.99	61.50	45.88
2618	17	248.08	206.72	365.12	435.59	63.28	47.21
2629	21	247.68	203.93	362.43	431.40	63.90	47.68
2626	18	388.31	72.50	401.40	408.11	67.61	50.46
2637	22	383.43	75.60	397.80	405.18	68.11	50.83
2622	19	259.83	31.13	263.51	265.37	104.51	78.14
2633	23	255.32	36.54	260.45	263.05	105.44	78.83

1

Left Handle

Aluminum 6061-T6

ALLOWABLE TENSION ULTIMATE IS 42000.00

ALLOWABLE TENSION YIELD IS 35000.00

FACTOR OF SAFETY FOR YIELD IS 1.25

FACTOR OF SAFETY FOR ULTIMATE IS 2.0

ELEMENT ID	LOAD CASE	TENSILE STRESS	SHEAR STRESS	PRINCIPAL STRESS	VONMISES STRESS	MINIMUM M.S. YIELD	MINIMUM M.S. ULTIMATE
11300	10	6568.71	959.81	6706.08	6775.81	3.13	2.10
11302	10	4692.56	754.85	4811.00	4871.30	4.75	3.31
11301	10	4377.15	757.38	4504.50	4569.50	5.13	3.60
11322	15	525.35	104.73	545.46	555.79	49.38	36.78
11321	15	515.32	20.07	516.10	516.49	53.21	39.66
11303	5	425.73	72.52	437.75	443.88	62.08	46.31
11320	15	439.37	19.55	440.24	440.67	62.54	46.65
11304	5	375.93	71.30	389.00	395.69	69.76	52.07
11319	15	364.94	19.03	365.93	366.43	75.41	56.31
11314	10	282.94	82.00	304.98	316.58	87.44	65.33
11313	10	289.03	73.58	306.68	315.88	87.64	65.48
11318	7	292.27	18.11	293.39	293.95	94.25	70.44
11305	5	261.65	69.75	279.08	288.20	96.16	71.87
11312	10	247.53	73.70	267.81	278.51	99.54	74.40
11315	10	201.27	84.65	232.13	249.01	111.45	83.34
11317	2	192.33	90.23	228.03	247.82	111.98	83.74
11311	10	201.88	73.83	226.00	238.97	116.17	86.88
11309	11	131.23	107.24	191.33	227.42	122.12	91.34
11308	11	74.06	121.14	163.70	222.50	124.84	93.38
11306	11	53.83	123.37	153.19	220.37	126.06	94.30
11307	11	36.29	122.23	141.71	214.79	129.36	96.77
11310	10	152.08	73.95	182.11	198.83	139.82	104.62
11316	10	96.39	87.30	147.91	179.31	155.15	116.12

1

Right Handle

Aluminum 6061-T6

ALLOWABLE TENSION ULTIMATE IS 42000.00
 ALLOWABLE TENSION YIELD IS 35000.00
 FACTOR OF SAFETY FOR YIELD IS 1.25
 FACTOR OF SAFETY FOR ULTIMATE IS 2.0

ELEMENT ID	LOAD CASE	TENSILE STRESS	SHEAR STRESS	PRINCIPAL STRESS	VONMISES STRESS	MINIMUM M.S. YIELD	MINIMUM M.S. ULTIMATE
11326	9	401.20	51.22	407.64	410.89	67.14	50.11
11327	5	310.79	77.63	329.10	338.63	81.69	61.02
11328	5	228.69	76.28	251.80	264.11	105.01	78.51
11325	6	197.96	90.29	232.96	252.28	109.99	82.24
11324	4	159.03	83.44	194.77	214.89	129.30	96.73
11344	4	178.62	58.99	196.34	205.78	135.07	101.05
11329	5	151.88	74.83	182.56	199.67	139.23	104.17
11331	3	87.50	71.23	127.34	151.25	184.12	137.84
11343	13	143.07	17.63	145.21	146.29	190.40	142.55
11330	5	70.45	73.66	116.87	145.74	191.13	143.10
11332	15	137.82	17.84	140.09	141.24	197.24	147.68
11333	16	109.63	13.02	111.16	111.93	249.16	186.62
11342	11	101.88	11.74	103.21	103.89	268.53	201.14
11334	16	95.25	13.14	97.03	97.93	284.90	213.43
11335	16	79.19	13.27	81.36	82.46	338.56	253.67
11341	3	77.43	13.24	79.63	80.75	345.74	259.05
11336	17	74.03	9.91	75.33	75.99	367.45	275.34
11339	21	72.09	6.40	72.66	72.94	382.87	286.90
11340	21	69.66	12.24	71.75	72.81	383.55	287.41
11338	9	59.00	5.51	59.51	59.77	467.46	350.34
11337	9	40.54	7.60	41.91	42.62	655.97	491.73
11323	10	2.26	0.56	2.39	2.46	11383.12	8537.09

1

Bottle Retention Plate Stiffener

Aluminum 7075-T7351

ALLOWABLE TENSION ULTIMATE IS 68000.00
 ALLOWABLE TENSION YIELD IS 57000.00
 FACTOR OF SAFETY FOR YIELD IS 1.25
 FACTOR OF SAFETY FOR ULTIMATE IS 2.0

ELEMENT ID	LOAD CASE	TENSILE STRESS	SHEAR STRESS	PRINCIPAL STRESS	VONMISES STRESS	MINIMUM M.S. YIELD	MINIMUM M.S. ULTIMATE
12833	11	14341.43	7390.61	17468.30	19223.42	1.37	0.77
12832	11	18100.60	1726.06	18263.73	18345.83	1.49	0.85
12867	23	17175.25	2242.40	17463.20	17608.93	1.59	0.93
12875	23	15174.78	2656.90	15626.51	15857.21	1.88	1.14
12876	23	13693.27	3271.78	14434.85	14819.56	2.08	1.29
12834	11	11018.39	3157.07	11858.86	12300.66	2.71	1.76
12877	23	10329.24	3179.66	11229.57	11705.73	2.90	1.90
12868	23	11458.16	1373.95	11620.61	11702.68	2.90	1.91
12869	15	10913.01	1557.36	11130.90	11241.44	3.06	2.02
12831	11	10519.18	556.26	10548.51	10563.21	3.32	2.22
12830	11	10004.61	809.98	10069.76	10102.49	3.51	2.37
12866	23	7622.61	3336.25	8876.54	9565.35	3.77	2.55
12870	15	9380.02	691.88	9430.78	9456.26	3.82	2.60
12878	23	7426.75	3041.32	8513.25	9105.24	4.01	2.73
12871	15	8508.79	1058.25	8638.43	8703.97	4.24	2.91
12915	19	7214.81	2438.49	7961.67	8360.16	4.45	3.07
12913	19	8116.07	1066.75	8253.93	8323.73	4.48	3.08

1

LEXAN Slot

LEXAN

ALLOWABLE TENSION ULTIMATE IS 9600.000
ALLOWABLE TENSION YIELD IS 9600.000
FACTOR OF SAFETY FOR YIELD IS 1.25
FACTOR OF SAFETY FOR ULTIMATE IS 2.0

ELEMENT ID	LOAD CASE	TENSILE STRESS	SHEAR STRESS	PRINCIPAL STRESS	VONMISES STRESS	MINIMUM M.S. YIELD	MINIMUM M.S. ULTIMATE
13017	20	1970.07	539.75	2108.25	2180.63	2.52	1.20
13016	19	855.44	904.82	1428.54	1785.46	3.30	1.69

5.3 Analysis Of Bolted Connections

Interface connection for the bolted joints between parts are checked based on fastener strength, bolt hole bearing, and shear tear-out strength. The MS for combined shear and tension, bearing and shear tear-out were computed by a customized FORTRAN program. The lowest MS for beam elements representing fasteners of the GDS are presented in Table 5.9.

The fastener that experiences the highest shear and tension stress is beam element 4688 under load case 8 and connects the front panel to the side panel. The bolt has a margin of 0.15.

Preload for the bolt is calculated using the following equation.

$$PLD_{\max} = \frac{(1 + \Gamma)T_{\max}}{K * D}$$

Where,

- Γ = Uncertainty factor
- T_{\max} = Maximum torque applied to the fastener
- K = Typical nut factor
- D = Diameter of fastener

The FORTRAN program calculates total tensile load by summing maximum preload and axial load (including heel/toe bending) via the following equation:

$$P_{\text{total}} = PLD_{\max} + f * n * FS * P_t * ff$$

where,

- n = Loading plane Factor
- f = Joint Stiffness =
- FS = Factor of Safety
- P_t = Total Axial Load
- K_j = Spring constant of joint material
- K_b = Spring constant of bolt
- ff = Fitting factor of 1.15

The MS is calculated based on the following interaction equation:

$$\frac{X^3}{A^3} + \frac{Y^2}{B^2} = 1$$

where,

- X = Shear load
- A = Allowable shear load
- Y = Tensile load
- B = Allowable tensile load

The maximum MS of safety for the GDS drawer are presented in Table 5.8.

TABLE 5.8 GDS MINIMUM MARGINS FOR FASTENERS

1
1

Top to Side

NAS1102E3-10 (160ksi); panel 7075-T7351

FASTENER HEAD DIA IS 0.3850000
 MINIMUM PLD IS 1326.000
 MAXIMUM PLD IS 1950.000
 FITTING FACTOR IS 1.150000
 LOADING PLANE FACTOR IS 0.5000000
 STIFFNESS PARAMETER IS (PHI) 0.5000000
 HOLE DIA IS 0.1940000
 SHEET THICKNESS IS 8.500000E-02 EDGE DISTANCE IS 0.2500000
 ALLOWABLE ULT AND YLD TENSION IS 3180.000 2385.000
 ALLOWABLE ULT AND YLD SHEAR IS 2232.000 1674.000
 $e/D = 1.288660$
 ULTIMATE BEARING ALLOWABLE = 71373.71
 YIELD BEARING ALLOWABLE = 55279.64
 ULT AND YLD FACTORS OF SAFETY ARE 2.000000 1.250000

FASTENER ID	LOAD CASE	TENSION	TENS+BEND	MINIMUM		MINIMUM		MINIMUM		MINIMUM	
		+PRELOAD ULTIMATE	+PRELOAD ULTIMATE	SHEAR LOAD	M.S. W/PLD YIELD	M.S. W/PLD ULTIMATE	BEARING YIELD	BEARING ULTIMATE	SHEAR TEAR-OUT		
4650	4	1951.60	1971.75	29.81	0.21	0.61	19.55	15.58	21.75		
4662	8	1951.43	1970.56	28.28	0.22	0.61	19.32	15.40	21.50		
4639	1	1951.33	1969.45	40.37	0.22	0.61	13.92	11.04	15.52		
4651	5	1951.32	1969.13	39.24	0.22	0.62	13.69	10.86	15.27		
4649	5	1953.49	1968.31	13.43	0.22	0.62	45.94	36.87	50.97		
4661	1	1953.27	1967.37	12.68	0.22	0.62	46.63	37.44	51.75		
4640	5	1952.22	1965.99	15.36	0.22	0.62	36.95	29.63	41.02		
4652	1	1952.20	1965.60	15.23	0.22	0.62	37.66	30.20	41.81		
4641	5	1952.51	1963.29	18.32	0.22	0.62	32.78	26.26	36.40		
4653	1	1952.50	1962.88	17.83	0.22	0.62	33.71	27.01	37.43		
4648	5	1952.87	1962.02	15.10	0.22	0.62	41.00	32.90	45.51		
4660	1	1952.88	1961.70	14.30	0.22	0.62	42.75	34.31	47.45		
4646	21	1952.75	1960.14	7.79	0.22	0.62	79.88	64.26	88.56		
4658	17	1952.75	1960.11	7.49	0.22	0.62	83.65	67.31	92.73		
4644	5	1951.27	1957.42	2.85	0.22	0.63	125.81	101.33	139.42		
4656	1	1951.24	1957.33	2.99	0.22	0.63	119.76	96.45	132.72		
4642	5	1950.94	1956.64	9.91	0.22	0.63	56.54	45.43	62.72		
4654	1	1950.91	1956.29	9.15	0.22	0.63	61.00	49.03	67.65		
4643	5	1950.79	1956.26	5.98	0.22	0.63	92.45	74.41	102.48		
4655	1	1950.82	1956.08	5.55	0.22	0.63	102.00	82.11	113.05		
4647	5	1950.72	1955.64	6.57	0.22	0.63	95.52	76.89	105.87		
4659	1	1950.69	1955.49	6.00	0.22	0.63	99.89	80.42	110.72		
4645	21	1951.65	1954.96	6.11	0.22	0.63	102.80	82.76	113.93		
4657	17	1951.65	1954.91	5.77	0.22	0.63	108.85	87.64	120.64		

MAXIMUM CONNECTOR TENSION IS 7.39
 MAXIMUM CONNECTOR SHEAR IS 43.16

1

Bottom to Side

NAS1102E3-14 (160ksi); panel 7075-T7351

FASTENER HEAD DIA IS 0.3850000
 MINIMUM PLD IS 1326.000
 MAXIMUM PLD IS 1950.000
 FITTING FACTOR IS 1.150000
 LOADING PLANE FACTOR IS 0.5000000
 STIFFNESS PARAMETER IS (PHI) 0.5000000
 HOLE DIA IS 0.2330000
 SHEET THICKNESS IS 0.2650000 EDGE DISTANCE IS 0.3750000
 ALLOWABLE ULT AND YLD TENSION IS 3180.000 2385.000
 ALLOWABLE ULT AND YLD SHEAR IS 2232.000 1674.000
 $e/D = 1.609442$
 ULTIMATE BEARING ALLOWABLE = 95424.90
 YIELD BEARING ALLOWABLE = 72687.66
 ULT AND YLD FACTORS OF SAFETY ARE 2.000000 1.250000

TENSION	TENS+BEND	MINIMUM	MINIMUM	MINIMUM	MINIMUM
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FASTENER ID	LOAD CASE	+PRELOAD ULTIMATE	+PRELOAD ULTIMATE	SHEAR LOAD	M.S. YIELD	W/PLD ULTIMATE	M.S. ULTIMATE	W/PLD ULTIMATE	BEARING YIELD	BEARING ULTIMATE	SHEAR TEAR-OUT
4601	1	1953.09	1978.03	110.78	0.21	0.60	27.18	22.13	28.64		
4608	6	1953.41	1983.20	9.70	0.21	0.60	245.71	201.43	258.48		
4613	5	1952.78	1976.44	106.50	0.21	0.61	28.32	23.05	29.83		
4620	2	1953.44	1981.81	8.69	0.21	0.61	247.11	202.57	259.95		
4605	22	1953.18	1980.60	5.51	0.21	0.61	144.74	118.58	152.28		
4617	18	1953.23	1979.84	5.04	0.21	0.61	158.83	130.14	167.09		
4603	22	1953.37	1979.26	9.63	0.21	0.61	123.76	101.36	130.21		
4615	18	1953.38	1978.47	8.55	0.21	0.61	135.68	111.14	142.75		
4610	6	1951.91	1974.16	22.23	0.21	0.61	137.52	112.66	144.69		
4622	2	1951.89	1972.56	20.91	0.21	0.61	145.57	119.26	153.16		
4602	7	1951.53	1969.99	51.63	0.22	0.61	59.47	48.61	62.60		
4614	3	1951.80	1969.28	48.23	0.22	0.61	63.73	52.11	67.08		
4607	6	1950.98	1969.40	10.57	0.22	0.62	194.97	159.79	205.11		
4606	6	1952.34	1968.97	6.20	0.22	0.62	153.65	125.89	161.65		
4619	2	1951.01	1968.55	10.14	0.22	0.62	208.21	170.66	219.04		
4604	22	1951.47	1968.55	8.06	0.22	0.62	165.74	135.81	174.36		
4618	2	1952.31	1968.25	6.09	0.22	0.62	165.02	135.22	173.61		
4616	18	1951.46	1967.94	7.40	0.22	0.62	191.24	156.73	201.19		
4609	6	1951.38	1967.47	22.76	0.22	0.62	136.18	111.56	143.28		
4621	2	1951.31	1966.44	21.36	0.22	0.62	145.18	118.94	152.75		
4611	6	1952.46	1962.63	19.72	0.22	0.62	157.35	128.93	165.54		
4623	2	1952.41	1961.37	18.52	0.22	0.62	167.55	137.30	176.28		
4624	17	1950.48	1955.98	3.10	0.22	0.63	567.65	465.58	597.07		
4612	21	1950.62	1955.76	3.01	0.22	0.63	574.44	471.15	604.21		

MAXIMUM CONNECTOR TENSION IS 8.33
MAXIMUM CONNECTOR SHEAR IS 110.78

1

Bottom to Front

NAS1102E3-14 (160ksi); panel 7075-T7351

FASTENER HEAD DIA IS 0.3850000
MINIMUM PLD IS 1326.000
MAXIMUM PLD IS 1950.000
FITTING FACTOR IS 1.150000
LOADING PLANE FACTOR IS 0.5000000
STIFFNESS PARAMETER IS (PHI) 0.5000000
HOLE DIA IS 0.2330000
SHEET THICKNESS IS 0.2650000 EDGE DISTANCE IS 0.3250000
ALLOWABLE ULT AND YLD TENSION IS 3180.000 2385.000
ALLOWABLE ULT AND YLD SHEAR IS 2232.000 1674.000
e/D = 1.394850
ULTIMATE BEARING ALLOWABLE = 80983.91
YIELD BEARING ALLOWABLE = 62722.82
ULT AND YLD FACTORS OF SAFETY ARE 2.000000 1.250000

FASTENER ID	LOAD CASE	TENSION ULTIMATE	TENS+BEND ULTIMATE	SHEAR LOAD	MINIMUM M.S. YIELD	MINIMUM W/PLD ULTIMATE	MINIMUM BEARING YIELD	MINIMUM BEARING ULTIMATE	MINIMUM SHEAR TEAR-OUT
4631	5	1955.35	1986.61	187.56	0.20	0.58	13.36	10.59	14.17
4625	1	1954.94	1985.45	171.56	0.21	0.58	14.70	11.67	15.59
4626	8	1954.42	1989.17	90.05	0.21	0.60	28.52	22.82	30.18
4630	4	1954.33	1986.97	90.43	0.21	0.60	27.92	22.34	29.55
4627	16	1952.27	1973.49	10.17	0.21	0.61	156.88	126.40	165.77
4629	12	1952.21	1973.04	10.54	0.21	0.61	157.48	126.88	166.40
4628	16	1951.99	1971.82	4.71	0.21	0.61	542.05	437.22	572.64

MAXIMUM CONNECTOR TENSION IS -9.31
MAXIMUM CONNECTOR SHEAR IS 187.56

1

Bottom to Back

NAS1102E3-14 (160ksi); panel 7075-T7351

FASTENER HEAD DIA IS 0.3850000
MINIMUM PLD IS 1326.000
MAXIMUM PLD IS 1950.000
FITTING FACTOR IS 1.150000

LOADING PLANE FACTOR IS 0.5000000
 STIFFNESS PARAMETER IS (PHI) 0.5000000
 HOLE DIA IS 0.2330000
 SHEET THICKNESS IS 0.2650000 EDGE DISTANCE IS 0.2500000
 ALLOWABLE ULT AND YLD TENSION IS 3180.000 2385.000
 ALLOWABLE ULT AND YLD SHEAR IS 2232.000 1674.000
 e/D = 1.072961
 ULTIMATE BEARING ALLOWABLE = 51853.01
 YIELD BEARING ALLOWABLE = 40160.66
 ULT AND YLD FACTORS OF SAFETY ARE 2.000000 1.250000

FASTENER	LOAD	TENSION	TENS+BEND		MINIMUM	MINIMUM	MINIMUM	MINIMUM	MINIMUM
ID	CASE	+PRELOAD	+PRELOAD	SHEAR	M.S. W/PLD	M.S. W/PLD	BEARING	BEARING	SHEAR
		ULTIMATE	ULTIMATE	LOAD	YIELD	ULTIMATE	YIELD	ULTIMATE	TEAR-OUT
4636	22	1953.57	1985.11	2.75	0.21	0.60	84.41	67.92	107.39
4633	18	1954.45	1969.08	3.30	0.22	0.62	114.63	92.31	145.74
4635	22	1953.70	1967.18	13.40	0.22	0.62	96.93	78.03	123.28
4634	18	1952.07	1963.43	4.01	0.22	0.62	113.42	91.33	144.21
4637	18	1953.14	1961.64	10.79	0.22	0.62	110.04	88.60	139.91
4632	17	1951.78	1956.81	16.35	0.22	0.63	103.92	83.67	132.15
4638	21	1951.79	1956.57	16.22	0.22	0.63	104.30	83.97	132.63

MAXIMUM CONNECTOR TENSION IS 7.74
 MAXIMUM CONNECTOR SHEAR IS 20.20

1

Slide to Side

NAS1101E3-7 (160ksi); panel 7075-T7351

FASTENER HEAD DIA IS 0.3130000
 MINIMUM PLD IS 1326.000
 MAXIMUM PLD IS 1950.000
 FITTING FACTOR IS 1.150000
 LOADING PLANE FACTOR IS 0.5000000
 STIFFNESS PARAMETER IS (PHI) 0.5000000
 HOLE DIA IS 0.2330000
 SHEET THICKNESS IS 0.1200000 EDGE DISTANCE IS 1.170000
 ALLOWABLE ULT AND YLD TENSION IS 3180.000 2385.000
 ALLOWABLE ULT AND YLD SHEAR IS 2232.000 1674.000
 e/D = 5.021459
 ULTIMATE BEARING ALLOWABLE = 113000.0
 YIELD BEARING ALLOWABLE = 81946.56
 ULT AND YLD FACTORS OF SAFETY ARE 2.000000 1.250000

FASTENER	LOAD	TENSION	TENS+BEND		MINIMUM	MINIMUM	MINIMUM	MINIMUM	MINIMUM
ID	CASE	+PRELOAD	+PRELOAD	SHEAR	M.S. W/PLD	M.S. W/PLD	BEARING	BEARING	SHEAR
		ULTIMATE	ULTIMATE	LOAD	YIELD	ULTIMATE	YIELD	ULTIMATE	TEAR-OUT
4703	19	1957.47	2140.10	200.34	0.15	0.47	6.96	5.86	22.16
4714	23	1957.69	2138.14	197.27	0.15	0.47	7.08	5.96	22.52
4694	18	1951.41	2104.71	197.81	0.16	0.49	7.06	5.94	22.45
4706	21	2021.64	2121.68	99.54	0.16	0.50	15.01	12.80	45.61
4705	22	1951.12	2097.13	188.64	0.16	0.50	7.45	6.28	23.59
4695	17	2024.29	2114.32	86.53	0.16	0.50	17.42	14.88	52.62
4710	24	1950.23	2048.61	69.98	0.19	0.55	21.78	18.63	65.29
4699	20	1950.13	2047.98	69.14	0.19	0.55	22.05	18.87	66.10
4702	22	1951.25	2032.59	67.05	0.19	0.56	22.77	19.49	68.20
4713	18	1951.07	2030.65	66.52	0.19	0.57	22.96	19.65	68.75
4693	23	1950.50	1991.76	49.96	0.21	0.60	30.90	26.49	91.85
4700	21	1950.32	1992.09	34.81	0.21	0.60	44.78	38.46	132.26
4711	17	1950.41	1992.06	35.02	0.21	0.60	44.52	38.23	131.49
4701	18	1950.43	1989.53	5.28	0.21	0.60	140.32	120.80	410.35
4712	22	1950.33	1988.14	5.48	0.21	0.60	141.85	122.12	414.79
4704	19	1950.43	1986.11	41.91	0.21	0.60	37.04	31.78	109.71
4697	21	1950.02	1983.15	18.22	0.21	0.60	66.04	56.78	194.14
4708	24	1950.06	1983.01	18.43	0.21	0.60	65.46	56.28	192.45
4707	24	1952.30	1978.02	29.86	0.21	0.61	52.38	45.00	154.36
4696	20	1952.15	1977.63	29.63	0.21	0.61	52.80	45.37	155.60
4709	17	1950.43	1975.87	26.31	0.21	0.61	59.40	51.05	174.80
4698	21	1950.34	1975.58	25.82	0.21	0.61	60.52	52.02	178.05

MAXIMUM CONNECTOR TENSION IS 151.44
 MAXIMUM CONNECTOR SHEAR IS 200.34

1

Side to Front

NAS1102E3-10 (160ksi); panel 7075-T7351

FASTENER HEAD DIA IS 0.3850000
MINIMUM PLD IS 1326.000
MAXIMUM PLD IS 1950.000
FITTING FACTOR IS 1.150000
LOADING PLANE FACTOR IS 0.5000000
STIFFNESS PARAMETER IS (PHI) 0.5000000
HOLE DIA IS 0.2330000
SHEET THICKNESS IS 8.5000001E-02 EDGE DISTANCE IS 0.3250000
ALLOWABLE ULT AND YLD TENSION IS 3180.000 2385.000
ALLOWABLE ULT AND YLD SHEAR IS 2232.000 1674.000
e/D = 1.394850
ULTIMATE BEARING ALLOWABLE = 80983.91
YIELD BEARING ALLOWABLE = 62722.82
ULT AND YLD FACTORS OF SAFETY ARE 2.000000 1.250000

FASTENER ID	LOAD CASE	TENSION +PRELOAD ULTIMATE	TENS+BEND +PRELOAD ULTIMATE	MINIMUM SHEAR LOAD	M.S. W/PLD YIELD	MINIMUM M.S. W/PLD ULTIMATE	MINIMUM BEARING YIELD	MINIMUM BEARING ULTIMATE	MINIMUM SHEAR TEAR-OUT
4688	8	1955.44	2074.16	359.42	0.15	0.42	1.40	0.94	1.54
4692	3	1954.88	2069.22	360.38	0.15	0.42	1.40	0.94	1.53
4685	8	1975.31	2004.45	27.37	0.20	0.59	24.29	19.41	25.72
4689	4	1975.12	2004.31	26.96	0.20	0.59	26.47	21.17	28.02
4687	15	1950.16	1971.15	68.39	0.21	0.61	11.64	9.20	12.35
4691	11	1950.35	1964.36	56.23	0.22	0.62	14.37	11.40	15.23
4686	11	1952.87	1961.18	30.37	0.22	0.62	23.03	18.39	24.38
4690	15	1952.73	1960.43	27.87	0.22	0.62	24.47	19.56	25.91

MAXIMUM CONNECTOR TENSION IS -44.01

MAXIMUM CONNECTOR SHEAR IS 360.38

1

Side to Back

NAS1102E3-10 (160ksi); panel 7075-T7351

FASTENER HEAD DIA IS 0.3850000
MINIMUM PLD IS 1326.000
MAXIMUM PLD IS 1950.000
FITTING FACTOR IS 1.150000
LOADING PLANE FACTOR IS 0.5000000
STIFFNESS PARAMETER IS (PHI) 0.5000000
HOLE DIA IS 0.2330000
SHEET THICKNESS IS 8.5000001E-02 EDGE DISTANCE IS 0.2500000
ALLOWABLE ULT AND YLD TENSION IS 3180.000 2385.000
ALLOWABLE ULT AND YLD SHEAR IS 2232.000 1674.000
e/D = 1.072961
ULTIMATE BEARING ALLOWABLE = 51853.01
YIELD BEARING ALLOWABLE = 40160.66
ULT AND YLD FACTORS OF SAFETY ARE 2.000000 1.250000

FASTENER ID	LOAD CASE	TENSION +PRELOAD ULTIMATE	TENS+BEND +PRELOAD ULTIMATE	MINIMUM SHEAR LOAD	M.S. W/PLD YIELD	MINIMUM M.S. W/PLD ULTIMATE	MINIMUM BEARING YIELD	MINIMUM BEARING ULTIMATE	MINIMUM SHEAR TEAR-OUT
4680	5	1963.49	1986.07	8.42	0.21	0.60	33.41	26.77	42.67
4684	1	1962.89	1984.65	8.11	0.21	0.60	33.32	26.70	42.56
4679	5	1952.09	1961.76	3.16	0.22	0.62	78.53	63.18	99.93
4683	1	1951.81	1960.73	3.06	0.22	0.62	82.89	66.70	105.46
4678	5	1952.17	1958.68	2.36	0.22	0.62	46.59	37.41	59.40
4682	1	1951.94	1957.83	2.08	0.22	0.62	46.21	37.10	58.92
4681	21	1950.36	1953.79	10.56	0.22	0.63	51.38	41.27	65.47
4677	17	1950.35	1953.58	10.14	0.22	0.63	53.57	43.03	68.25

MAXIMUM CONNECTOR TENSION IS 24.54

MAXIMUM CONNECTOR SHEAR IS 16.12

1

Front panel to bracket bolts

CREW A286 .250-20UNC

FASTENER HEAD DIA IS 0.3750000
MINIMUM PLD IS 2413.000
MAXIMUM PLD IS 2839.000
FITTING FACTOR IS 1.150000
LOADING PLANE FACTOR IS 0.5000000
STIFFNESS PARAMETER IS (PHI) 0.5000000
HOLE DIA IS 0.2720000
SHEET THICKNESS IS 0.1250000 EDGE DISTANCE IS 0.5000000
ALLOWABLE ULT AND YLD TENSION IS 5090.000 4241.000
ALLOWABLE ULT AND YLD SHEAR IS 3054.000 2545.000
e/D = 1.838235
ULTIMATE BEARING ALLOWABLE = 105720.6
YIELD BEARING ALLOWABLE = 78111.63
ULT AND YLD FACTORS OF SAFETY ARE 2.000000 1.250000

FASTENER ID	LOAD CASE	TENSION +PRELOAD ULTIMATE	TENS+BEND +PRELOAD ULTIMATE	SHEAR LOAD	MINIMUM M.S. W/PLD	MINIMUM M.S. W/PLD	MINIMUM BEARING ULTIMATE	MINIMUM BEARING ULTIMATE	MINIMUM SHEAR TEAR-OUT
11400	7	3111.35	3483.83	222.45	0.31	0.45	7.31	6.03	8.28
11401	3	3108.27	3366.84	222.84	0.34	0.50	7.29	6.01	8.27

MAXIMUM CONNECTOR TENSION IS -473.65
MAXIMUM CONNECTOR SHEAR IS 222.84

6.0 Crew Induced loads

While in orbit, the front panel of the GDS and the guide assembly are exposed to crew-induced loads as defined in Table 3.1.13-1 of SSP 57000 Rev D.

TABLE 6.1 CREW INDUCED LOADS

CREW SYSTEM OR STRUCTURE	TYPE OF LOAD	LOAD	DIRECTION OF LOAD
Levers, Handles, Operating Wheels, Controls	Push or Pull concentrated on most extreme edge	222.6 N (50 lbf), limit	Any direction
Small Knobs	Twist (torsion)	14.9 N-m (11 ft-lbf), limit	Either direction
Exposed Utility Lines (Gas, Fluid, and Vacuum)	Push or Pull	222.6 N (50 lbf)	Any direction
Rack front panels and any other normally exposed equipment	Load distributed over a 4 inch by 4 inch area	556.4 N (125 lbf), limit	Any direction

Legend:
ft = feet, m = meter, N = Newton, lbf = pounds force

The front panel and handles were analyzed using these kick loads. FEA was used to analyze the 125 lbf kick load on the front panel. The results of the FEA analysis can be seen in Figure 6.1. The FEA gives a maximum stress of 6090 psi, which gives a margin of 0.89 for the front panel kick load.

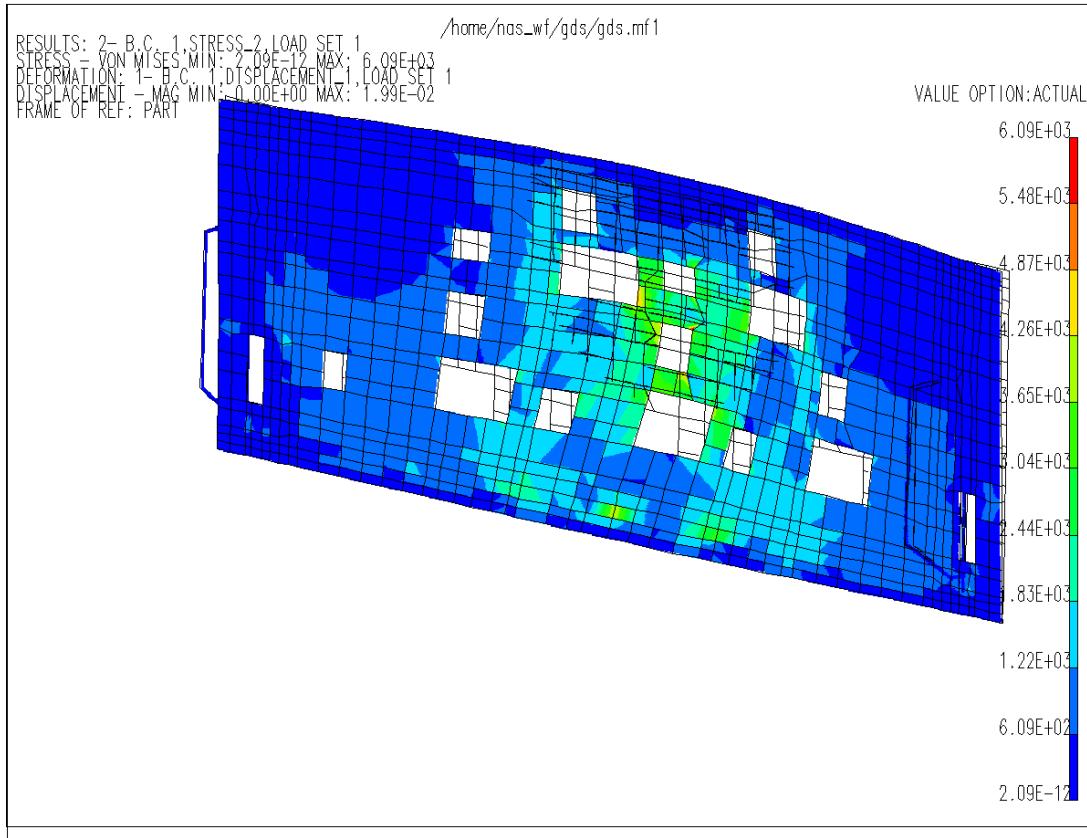


FIGURE 6.1 FEA ANALYSIS FOR THE FRONT PANEL 125 LBF KICK LOAD

7.0 DEPRESSURIZATION/REPRESSURIZATION

For depressurization/repressurization analysis, it must be shown that the component can withstand the maximum expected rate of depressurization/repressurization without structural failure. The depressurization/repressurization rates are given in SSP 57000 Rev D.

A customized FORTRAN program is used to perform the depressurization/repressurization analysis and the results can be seen in Tables 7.1 and 7.2. An enveloping rate of 9.0 psi/min was used. The tables give a maximum delta pressure that is then used to calculate the maximum stress caused by the depressurization/repressurization.

The analysis gives a maximum delta pressure of 2.07E-7 psi which is a negligible delta pressure.

TABLE 7.1 DEPRESSURIZATION OUTPUT SUMMARY

```

gds      - DEPRESSURIZATION ANALYSIS
TOTAL VOLUME =   1224.000    IN**3
TOTAL LEAK AREA =   3.250000   IN**2
DEPRESSURIZATION RATE =   9.000000   PSI/MIN
PRESSURE AT START OF SIMULATION =   16.00000   PSI
PRESSURE AT END OF SIMULATION =  0.0000000E+00 PSI
TIME STEP =  1.0000000E-03 SEC

TIME (SECS) PINSIDE POUTSIDE PDELTA MINSIDE MEXITING
 0.0000 16.0000 16.0000 0.00E+00 0.0577 0.00E+00
 1.0000 15.8502 15.8502 0.00E+00 0.0572 0.00E+00
 2.0000 15.7001 15.7001 0.00E+00 0.0566 0.00E+00
 3.0000 15.5502 15.5502 0.00E+00 0.0561 0.00E+00
 3.9999 15.4002 15.4002 0.00E+00 0.0556 0.00E+00
 4.9998 15.2502 15.2502 0.00E+00 0.0550 0.00E+00
 5.9997 15.1002 15.1002 0.00E+00 0.0545 0.00E+00
 6.9997 14.9502 14.9502 0.00E+00 0.0539 0.00E+00
 7.9996 14.8002 14.8002 0.00E+00 0.0534 0.00E+00
 9.0000 14.6503 14.6501 0.14E-03 0.0529 0.44E-05
10.0004 14.5001 14.5001 0.00E+00 0.0523 0.00E+00
11.0008 14.3500 14.3500 0.00E+00 0.0518 0.00E+00
12.0012 14.2000 14.2000 0.00E+00 0.0512 0.00E+00
13.0016 14.0499 14.0499 0.00E+00 0.0507 0.00E+00
14.0020 13.8998 13.8998 0.00E+00 0.0502 0.00E+00
15.0024 13.7498 13.7498 0.00E+00 0.0496 0.00E+00
16.0028 13.5998 13.5997 0.11E-03 0.0491 0.42E-05
17.0023 13.4498 13.4498 0.00E+00 0.0485 0.00E+00
...
 83.9655 3.4053 3.4053 0.00E+00 0.0123 0.00E+00
 84.9649 3.2554 3.2554 0.00E+00 0.0117 0.00E+00
 85.9644 3.1055 3.1055 0.00E+00 0.0112 0.00E+00
 86.9638 2.9556 2.9556 0.00E+00 0.0107 0.00E+00
 87.9633 2.8057 2.8057 0.00E+00 0.0101 0.00E+00
 88.9627 2.6557 2.6557 0.00E+00 0.0096 0.00E+00
 89.9622 2.5058 2.5058 0.00E+00 0.0090 0.00E+00
 90.9616 2.3559 2.3559 0.00E+00 0.0085 0.00E+00
 91.9611 2.2060 2.2060 0.00E+00 0.0080 0.00E+00
 92.9605 2.0561 2.0561 0.00E+00 0.0074 0.00E+00
 93.9600 1.9062 1.9062 0.38E-04 0.0069 0.16E-05
 94.9594 1.7563 1.7562 0.24E-04 0.0063 0.15E-05
 95.9589 1.6065 1.6063 0.14E-03 0.0058 0.14E-05
 96.9583 1.4565 1.4564 0.66E-04 0.0053 0.14E-05
 97.9578 1.3066 1.3065 0.10E-03 0.0047 0.13E-05
 98.9572 1.1567 1.1566 0.11E-03 0.0042 0.12E-05
 99.9567 1.0067 1.0066 0.55E-04 0.0036 0.11E-05
100.9561 0.8569 0.8567 0.16E-03 0.0031 0.11E-05
101.9556 0.7068 0.7068 0.00E+00 0.0026 0.00E+00
102.9550 0.5569 0.5569 0.00E+00 0.0020 0.00E+00
103.9545 0.4072 0.4070 0.21E-03 0.0015 0.73E-06
104.9539 0.2571 0.2571 0.00E+00 0.0009 0.00E+00
105.9534 0.1073 0.1071 0.16E-03 0.0004 0.54E-06

MAXIMUM DELTA PRESSURE =  2.0778179E-04
TIME = 103.9545

```

TABLE 7.2 REPRESSURIZATION OUTPUT SUMMARY

```

gds      - REPRESSURIZATION ANALYSIS
TOTAL VOLUME =   1224.000    IN**3
TOTAL LEAK AREA =   3.250000    IN**2
REPRESSURIZATON RATE =   9.000000    PSI/MIN
PRESSURE AT START OF SIMULATION =  0.0000000E+00 PSI
PRESSURE AT END OF SIMULATION =   16.00000    PSI
TIME STEP =  1.0000000E-03 SEC

```

TIME (SECS)	PINSIDE	POUTSIDE	PDELTA	MINSIDE	MEXITING
0.0000	0.0000	0.0000	0.00E+00	0.0000	0.00E+00
1.0000	0.1498	0.1498	0.77E-04	0.0005	0.54E-06
2.0000	0.2998	0.2999	0.68E-04	0.0011	0.91E-06
3.0000	0.4498	0.4498	0.00E+00	0.0016	0.00E+00
3.9999	0.5998	0.5998	0.80E-04	0.0022	0.88E-06
4.9998	0.7498	0.7498	0.00E+00	0.0027	0.00E+00
5.9997	0.8998	0.8998	0.00E+00	0.0032	0.00E+00
6.9997	1.0497	1.0498	0.81E-04	0.0038	0.12E-05
7.9996	1.1997	1.1998	0.13E-03	0.0043	0.12E-05
9.0000	1.3497	1.3499	0.13E-03	0.0049	0.13E-05
10.0004	1.4999	1.4999	0.00E+00	0.0054	0.00E+00
11.0008	1.6499	1.6500	0.81E-04	0.0060	0.15E-05
12.0012	1.8000	1.8000	0.11E-04	0.0065	0.15E-05
13.0016	1.9501	1.9501	0.26E-04	0.0070	0.16E-05
14.0020	2.1002	2.1002	0.00E+00	0.0076	0.00E+00
15.0024	2.2501	2.2502	0.77E-04	0.0081	0.17E-05
16.0028	2.4003	2.4003	0.00E+00	0.0087	0.00E+00
17.0023	2.5502	2.5502	0.00E+00	0.0092	0.00E+00
18.0017	2.7001	2.7001	0.00E+00	0.0097	0.00E+00
19.0012	2.8500	2.8500	0.00E+00	0.0103	0.00E+00
20.0006	2.9999	2.9999	0.00E+00	0.0108	0.00E+00
...					
80.9671	12.1449	12.1449	0.00E+00	0.0438	0.00E+00
81.9666	12.2948	12.2948	0.00E+00	0.0444	0.00E+00
82.9660	12.4448	12.4448	0.00E+00	0.0449	0.00E+00
83.9655	12.5947	12.5947	0.00E+00	0.0454	0.00E+00
84.9649	12.7446	12.7446	0.00E+00	0.0460	0.00E+00
85.9644	12.8945	12.8945	0.00E+00	0.0465	0.00E+00
86.9638	13.0444	13.0444	0.00E+00	0.0471	0.00E+00
87.9633	13.1943	13.1943	0.00E+00	0.0476	0.00E+00
88.9627	13.3443	13.3443	0.00E+00	0.0481	0.00E+00
89.9622	13.4942	13.4942	0.00E+00	0.0487	0.00E+00
90.9616	13.6441	13.6441	0.00E+00	0.0492	0.00E+00
91.9611	13.7940	13.7940	0.00E+00	0.0498	0.00E+00
92.9605	13.9439	13.9439	0.13E-04	0.0503	0.43E-05
93.9600	14.0938	14.0938	0.00E+00	0.0508	0.00E+00
94.9594	14.2438	14.2438	0.00E+00	0.0514	0.00E+00
95.9589	14.3937	14.3937	0.00E+00	0.0519	0.00E+00
96.9583	14.5436	14.5436	0.00E+00	0.0525	0.00E+00
97.9578	14.6935	14.6935	0.00E+00	0.0530	0.00E+00
98.9572	14.8433	14.8434	0.14E-03	0.0536	0.44E-05
99.9567	14.9933	14.9934	0.84E-04	0.0541	0.44E-05
100.9561	15.1433	15.1433	0.00E+00	0.0546	0.00E+00
101.9556	15.2932	15.2932	0.00E+00	0.0552	0.00E+00
102.9550	15.4431	15.4431	0.00E+00	0.0557	0.00E+00
103.9545	15.5930	15.5930	0.00E+00	0.0563	0.00E+00
104.9539	15.7429	15.7429	0.00E+00	0.0568	0.00E+00
105.9534	15.8929	15.8929	0.00E+00	0.0573	0.00E+00

MAXIMUM DELTA PRESSURE = 1.3923645E-04
 TIME = 98.95724

8.0 FRACTURE CONTROL

The following applies only to the drawer and structures within the drawer. It is **not** a fracture control analysis of the pressure vessels.

8.1 Containment

Engineering judgment was used to determine that the containment is not an issue with the GDS for the following reasons:

- The internal components are constrained by foam and a bottle retention plate.
- There is not enough space within the drawer for the internal components to achieve the velocities necessary to breech the drawer.

8.2 Fail-Safe Analysis

- Fail-safe analysis has been performed for the drawer
- The lowest margin front panel rack attachment bolt qualifies for this analysis
- The static analysis is re-performed with the lowest margin rack bolt removed
- A margin of safety of 0.25 is obtained for the remaining fasteners
- All the panels and stiffeners are reanalyzed and the results show positive margins of safety
- $FS = 1.0$ for fail-safe

The drawer structure is fail-safe, the content is contained: the GDS drawer is thus non-fracture critical.

8.3 Fatigue Analysis

Fatigue analysis was performed using the program NASGRO. The analysis was performed using an initial crack size of 0.005 at the location of the highest stress. Using the Goddard Spectrum and a scatter factor of 4, NASGRO returned a fatigue life of 100 missions.

9.0 Summary

Structural assessment has been performed on the GDS drawer. Positive margins of safety were obtained on the drawer for nominal lift-off loading conditions, depressurization/repressurization and crew induced loading. Fatigue analysis shows the drawer has a fatigue life of 100 missions. Fracture screening indicates the component is non-fracture critical.

Open structural analysis on the drawer includes integrated rack-level analysis and fracture control analysis on the pressure system. Due to the rack post induced load, margins of safety, fatigue life, and fail-safe margins are expected to be reduced.

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